Havnivåstigning og kystendringer i det 21. århundret på Jorda, i Norge og i Bergen

William Helland-Hansen

Equinor seniorforening

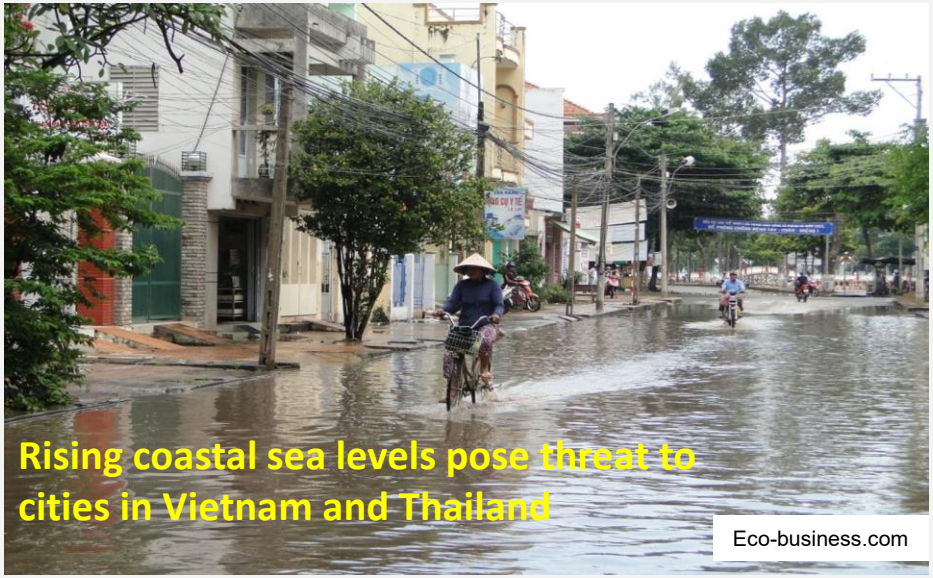
7 januar 2026

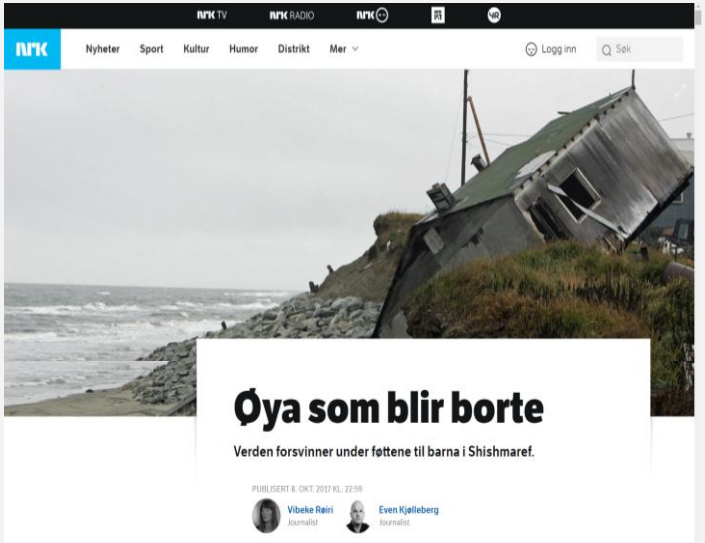
Institutt for geovitenskap
Department of Earth Science

This talk:

Global perspective – 21 century

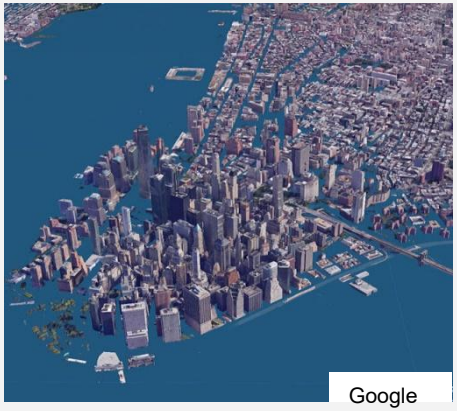
- Why coastal change (and not only sea-level change)?
- Go through the individual drivers for coastal change
- What are the effect of the combination of these drivers?
- Which coasts are most exposed?
- What about Bergen and Norway?

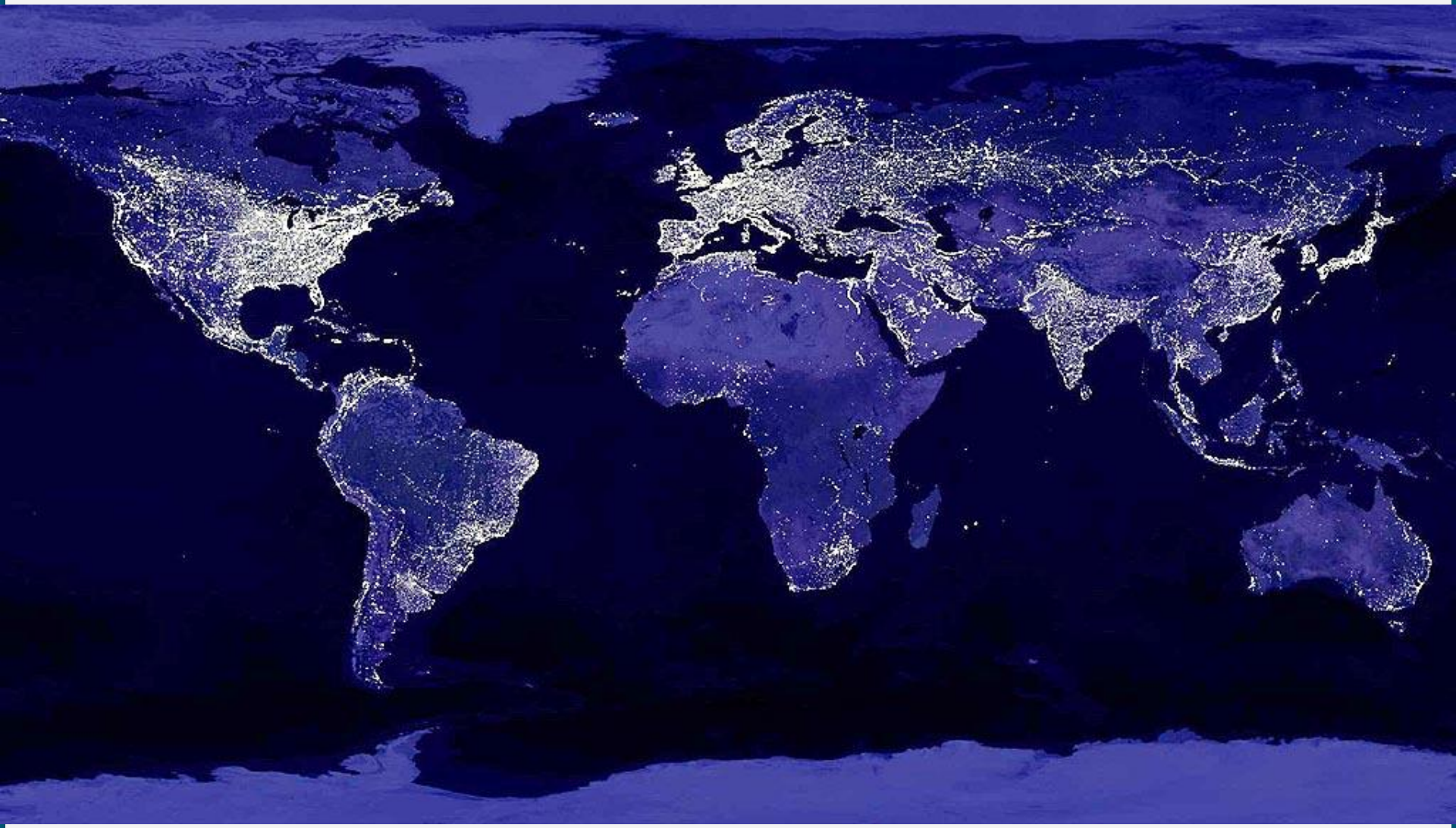

Rising coastal sea levels pose threat to cities in Vietnam and Thailand
Eco-business.com


NRK
Nyheter
Sport
Kultur
Humor
Distrikt
Mer
Øya som blir borte
Verden forsvinner under føttene til barna i Shishmaref.
Vibeke Røiri
Even Kjølleberg


Florida is drowning. Condos are still being built. Can't humans see the writing on the wall?
The Guardian

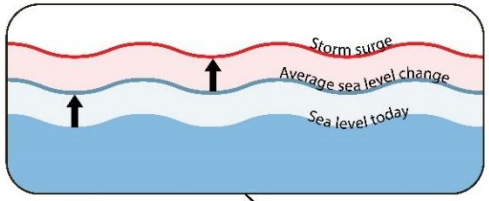

BBC
NEWS
Home | Coronavirus | Video | World | UK | Business | Tech | Science | Stories | Entertainment & Arts | Health
Science
Solutions to the global noncommunicable diseases epidemic
Coastal floods warning in UK as sea levels rise
Climate change
PA MEDIA
Storm Ciara brought widespread flooding


Google Earth

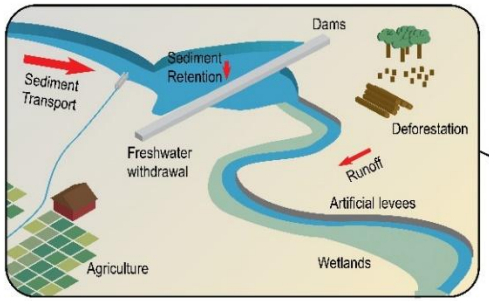


NASA

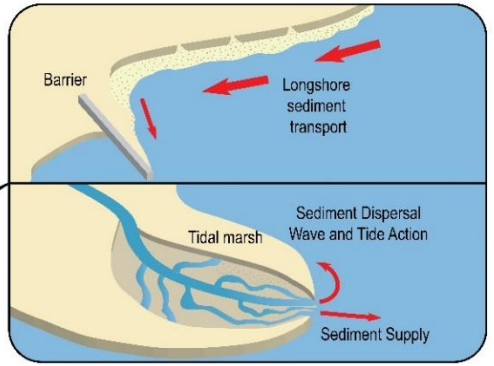
1. Global sea-level changes

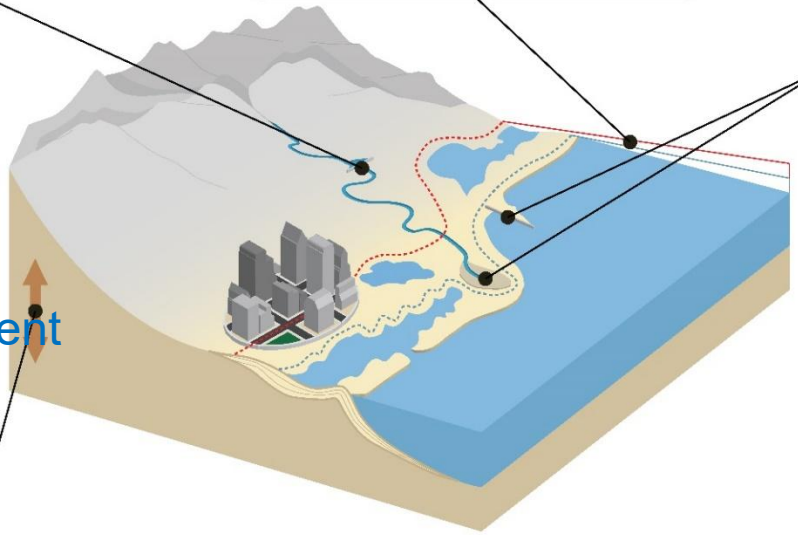


3. Sediment supply

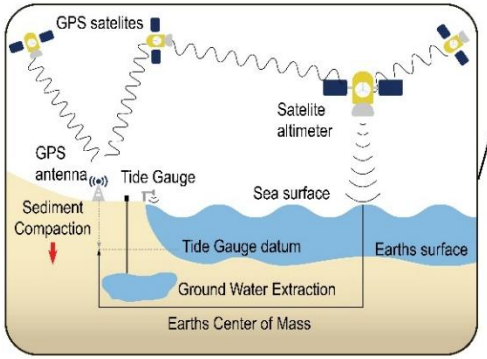


4. Sediment distribution



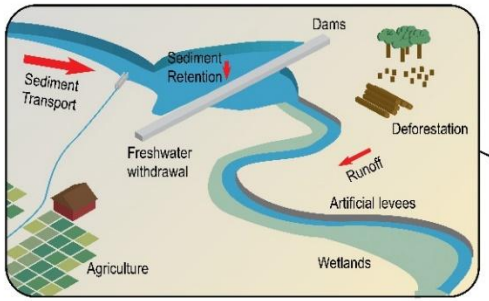


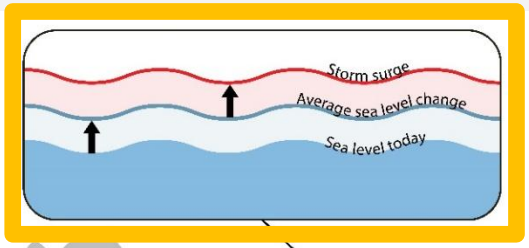
2. Vertical land movement

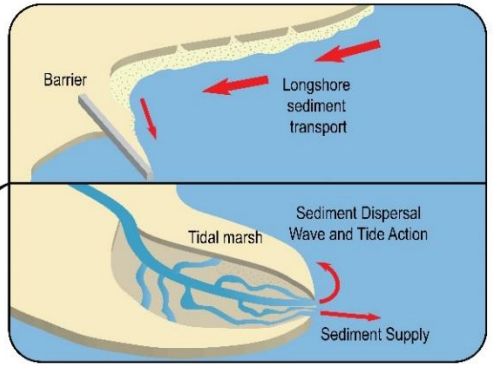


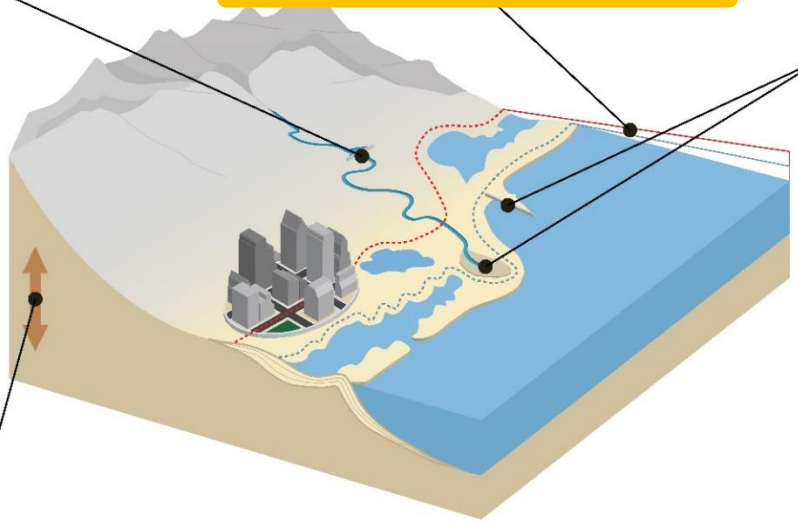
COASTAL CHANGE

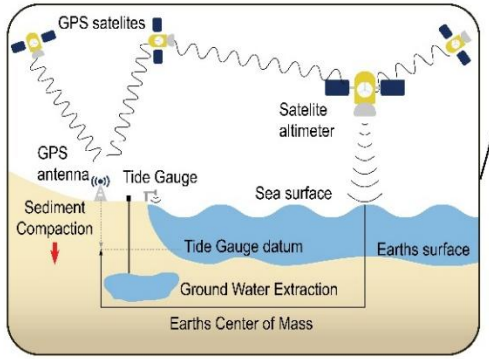
Global sea-level change











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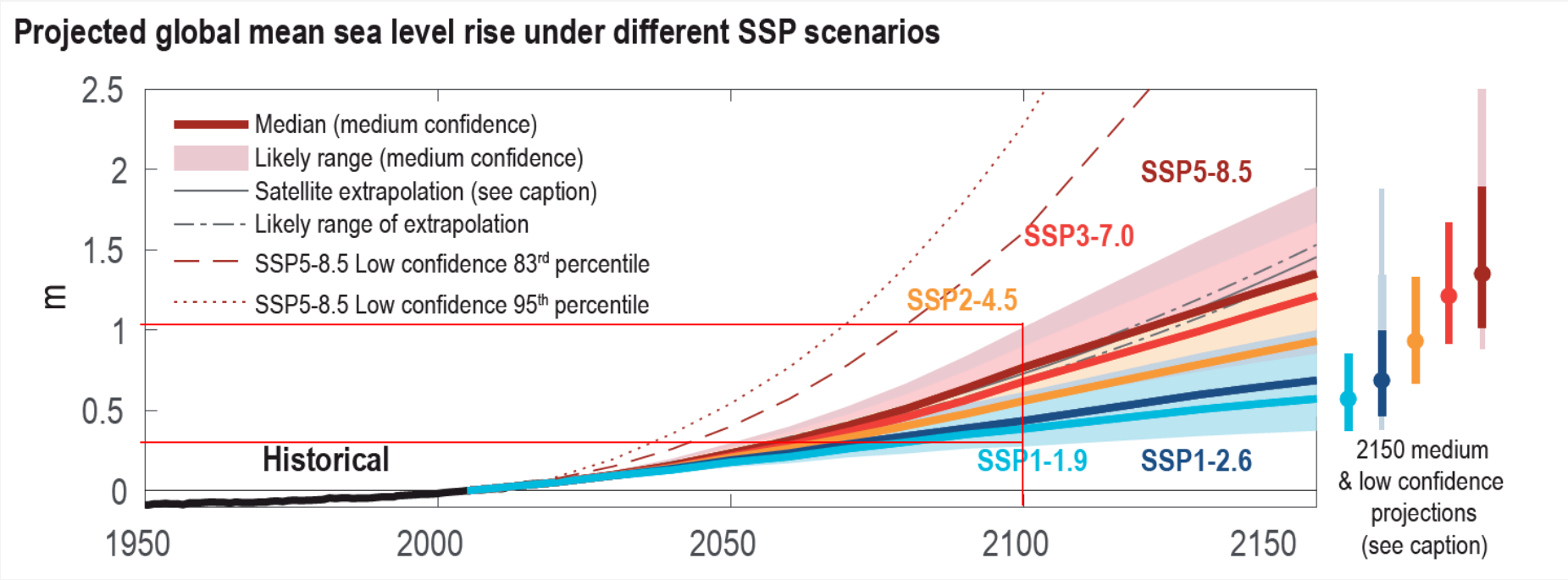
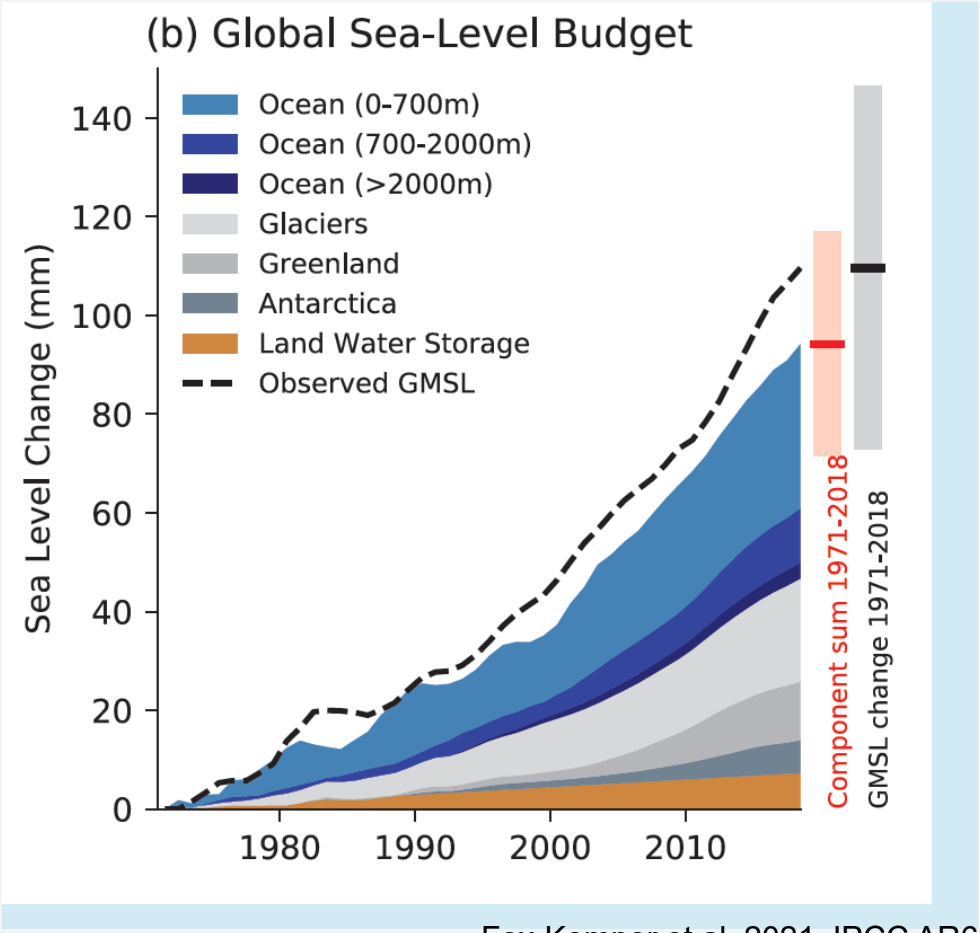


Fox-Kemper et al. 2021, IPCC AR6

Global sea-level change



Fox-Kemper et al. 2021, IPCC AR6

2006-2018

- Melting og ice sheets and glaciers: 44%
  - Glaciers: 17%
  - Greenland: 17%
  - Antarctica: 10%
- Expansion of sea-water due to heating: 39%
- Ground-water depletion: 17%

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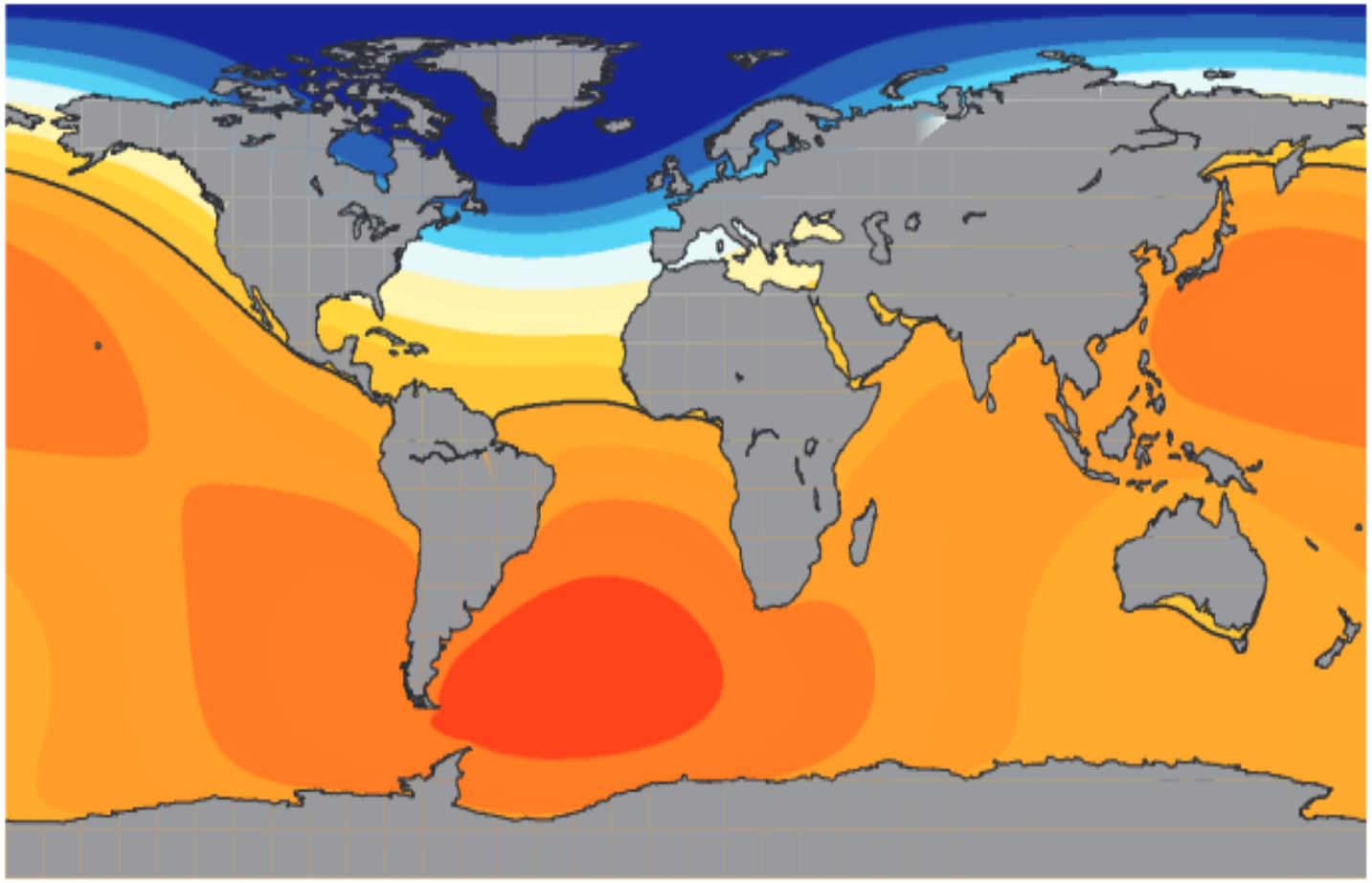
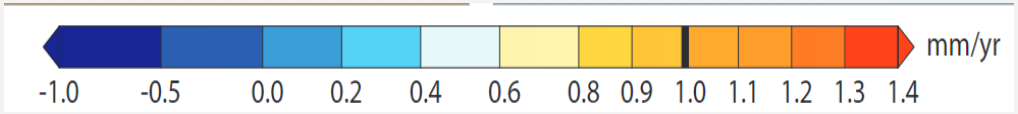
Global sea-level change





Tamisiea and Mitrovica, 2011

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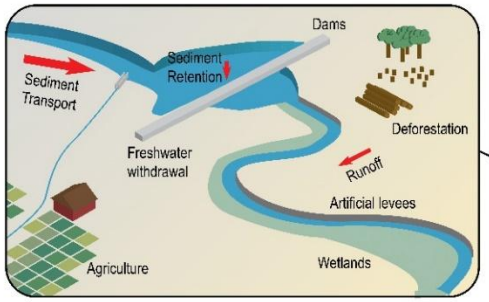
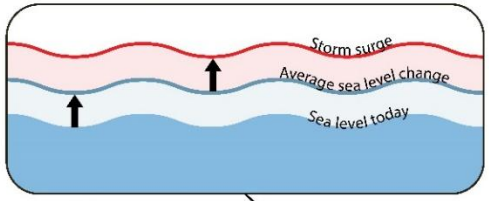
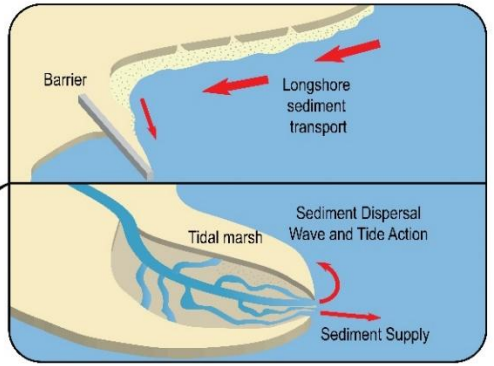
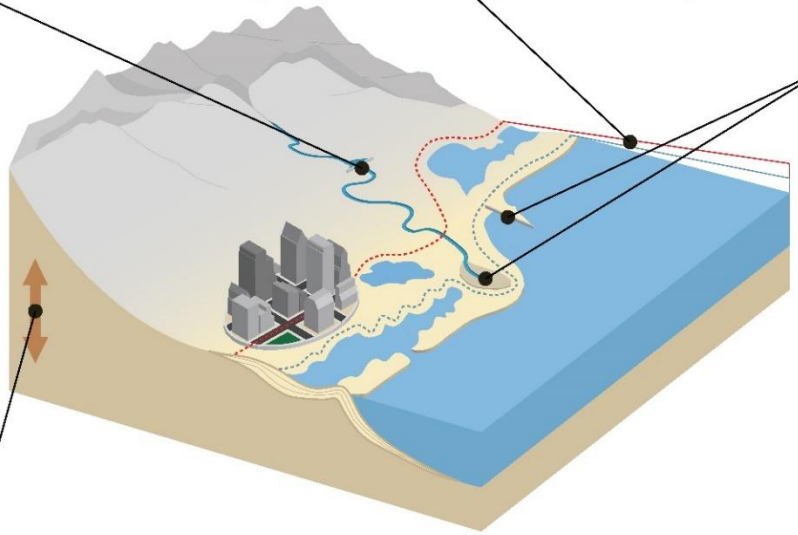
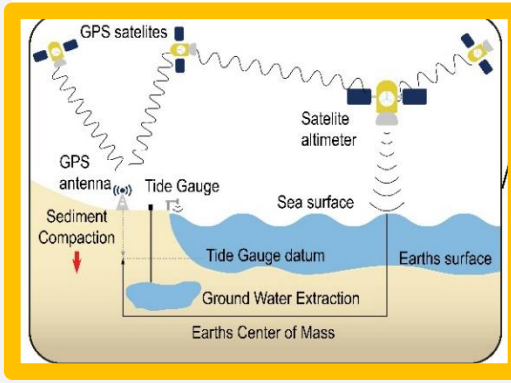
Vertical land movements











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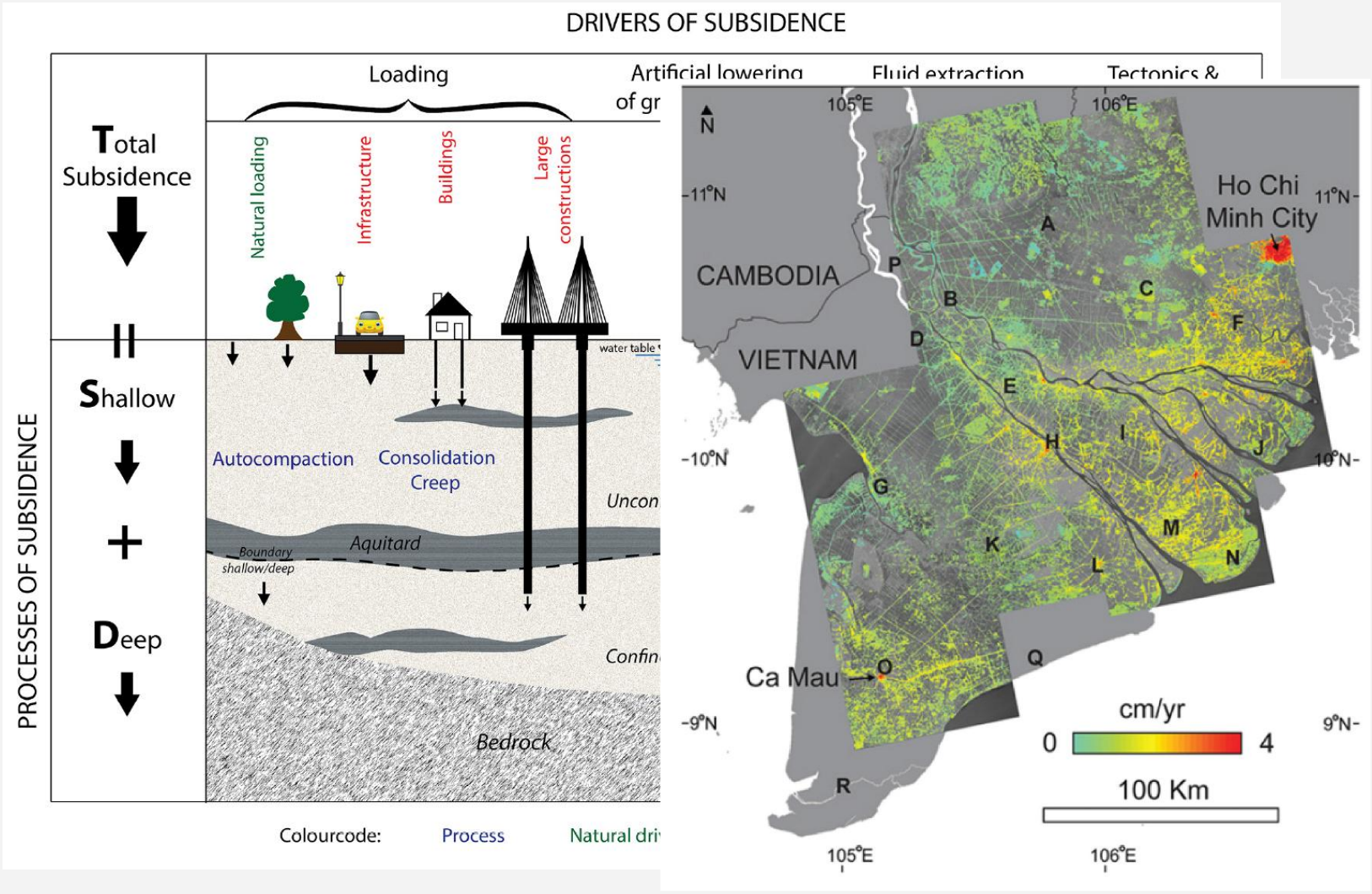
Vertical land movements



Philip Minderhoud et al., 2015

Dagbladet DB BERGEN DB TRONDHEIM PLUSS

Ny studie:

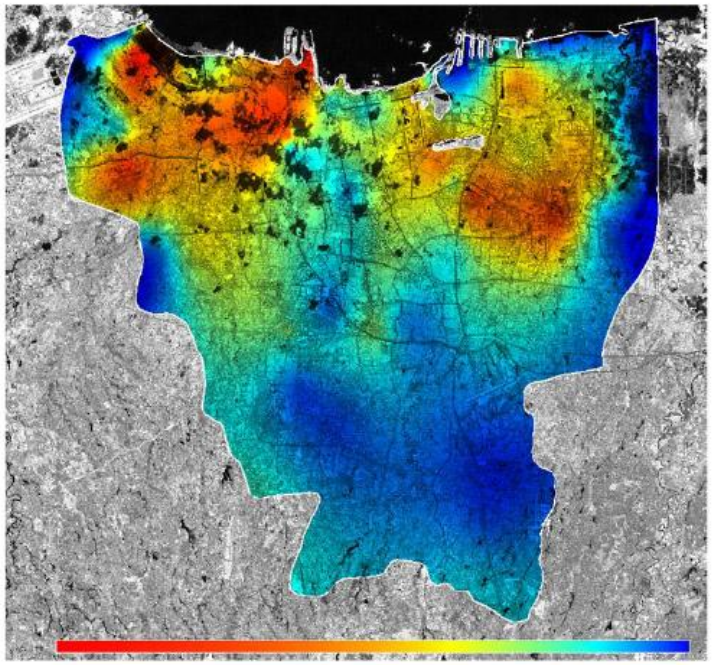
Storbyen synker

Forskere er bekymret for at New York synker under sin egen tyngde.

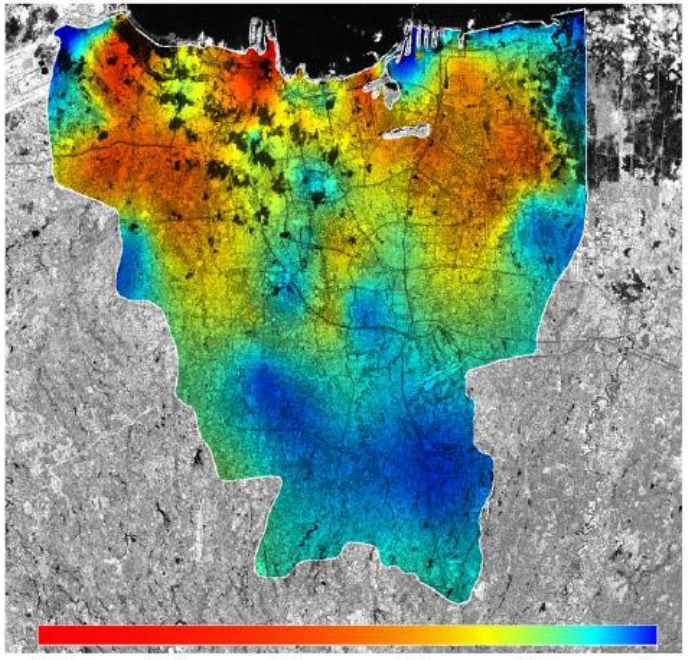
RISIKO: Forskere er bekymret for at tyngden av New York, her sett fra Rockefeller-bygningen, gjør at byen synker - enkelte deler med flere

Dagbladet,
19.5.2023

Vertical land movements



1974-1991

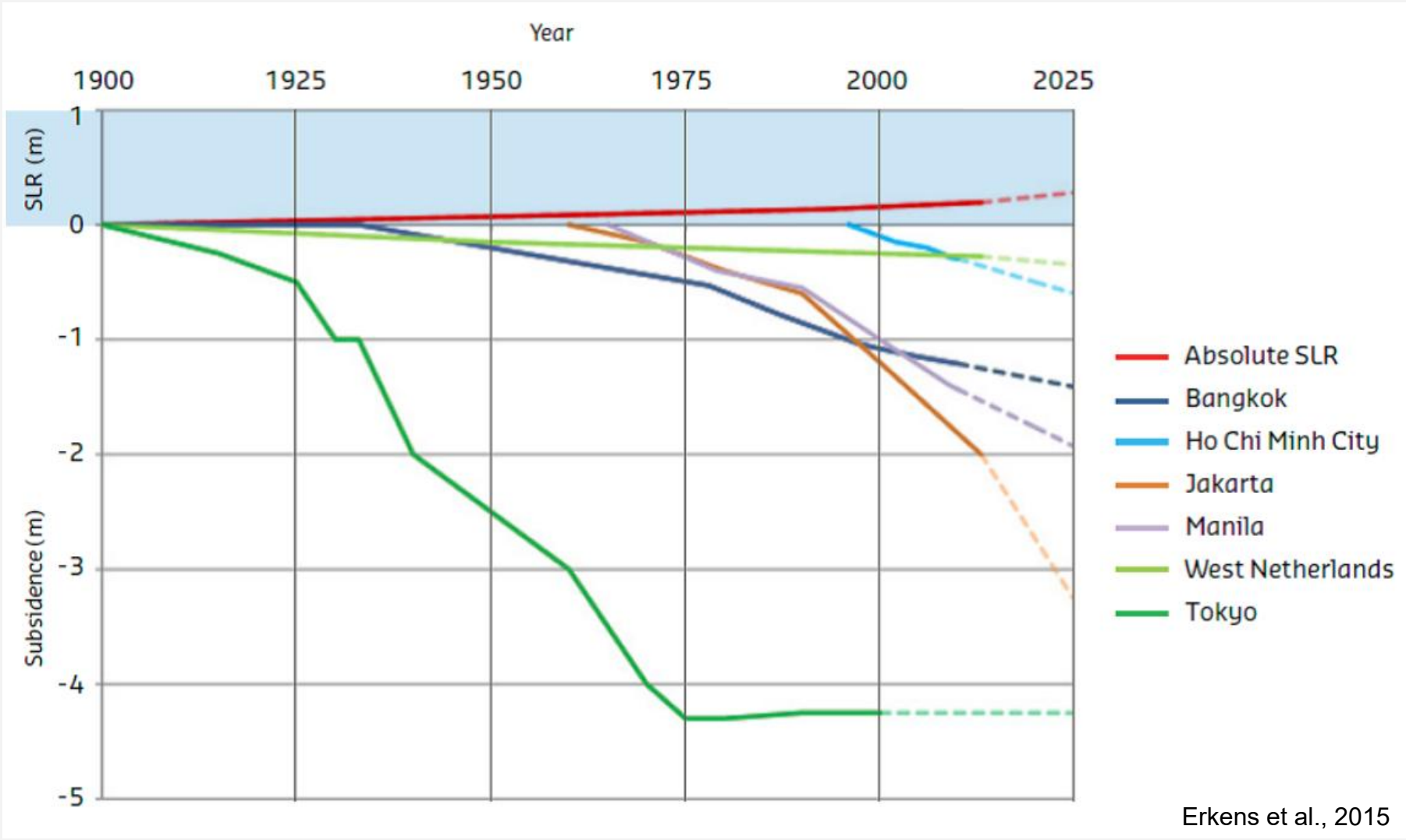


1991-2010

Abidin et al., 2015

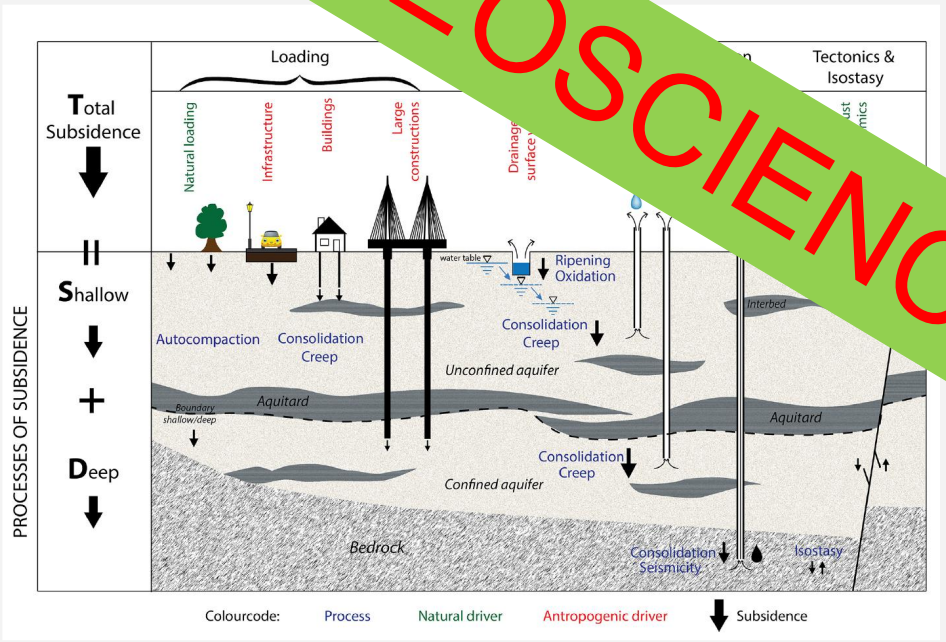
Reynold Sumayku / Alamy Stock Photo

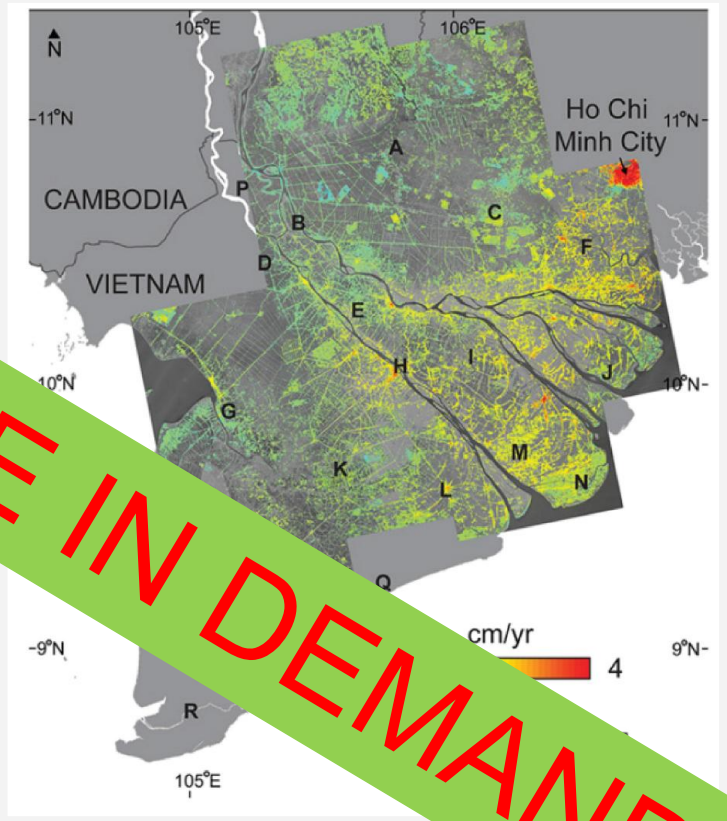
Vertical land movements



Erkens et al., 2015

Vertical land movements





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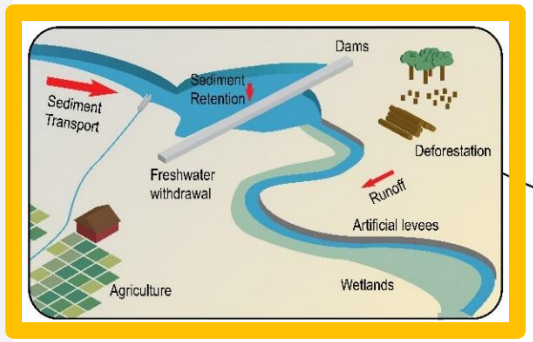
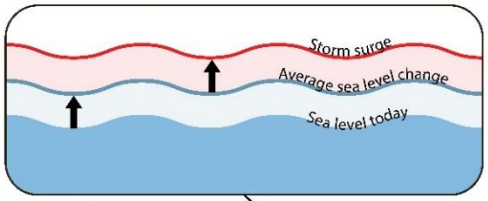
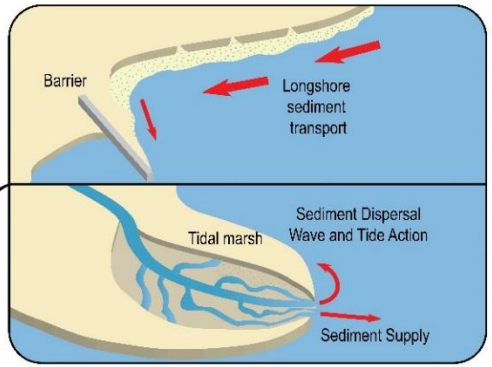
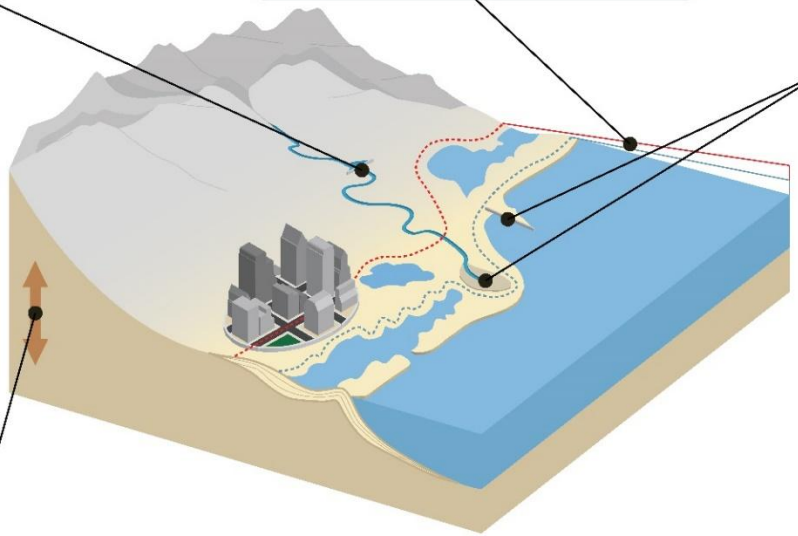
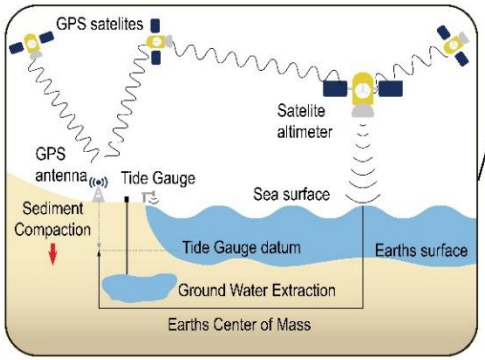
Minderhoud et al., 2015











COASTAL CHANGE

Sediment supply

Blum and Roberts, 2009

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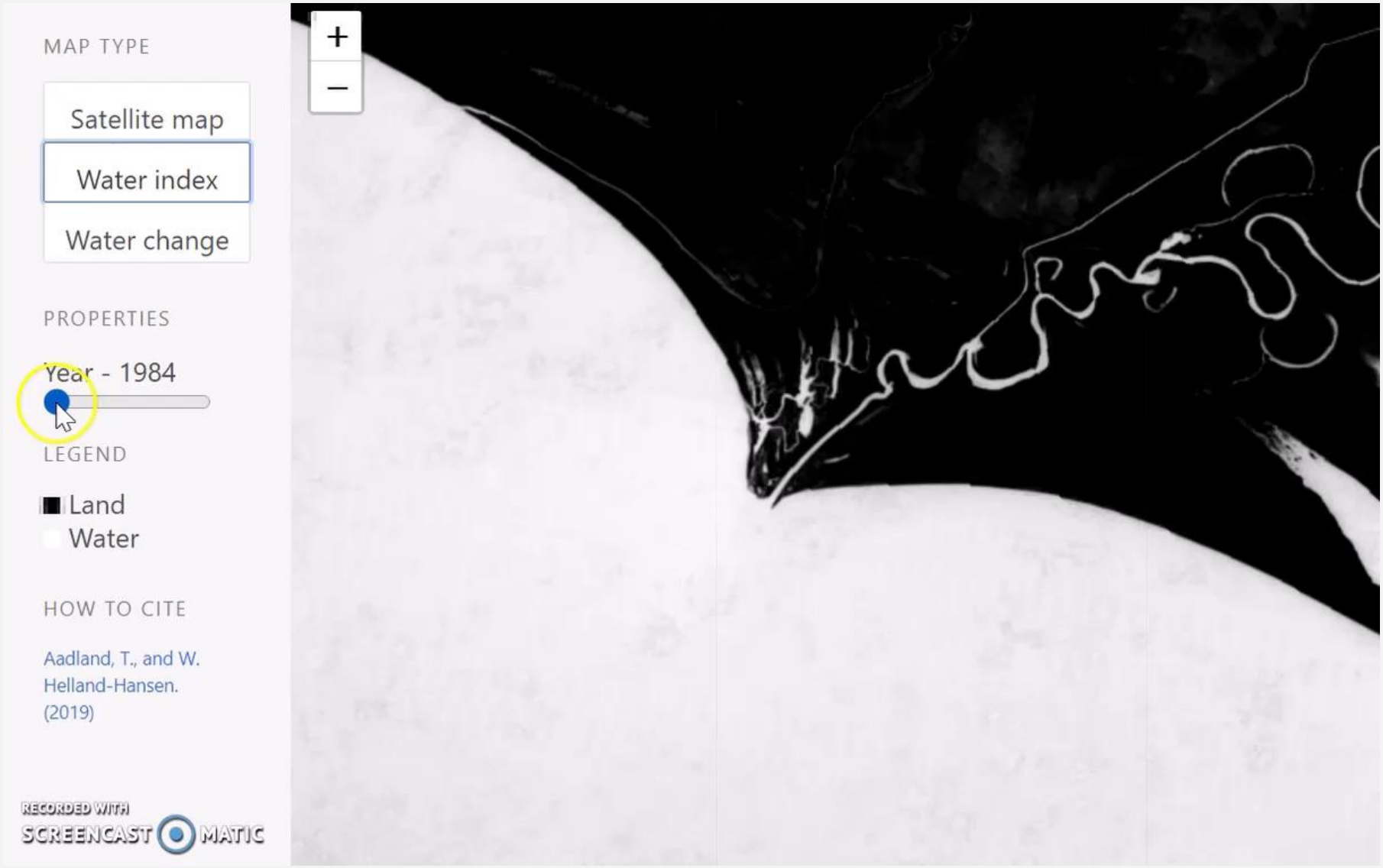
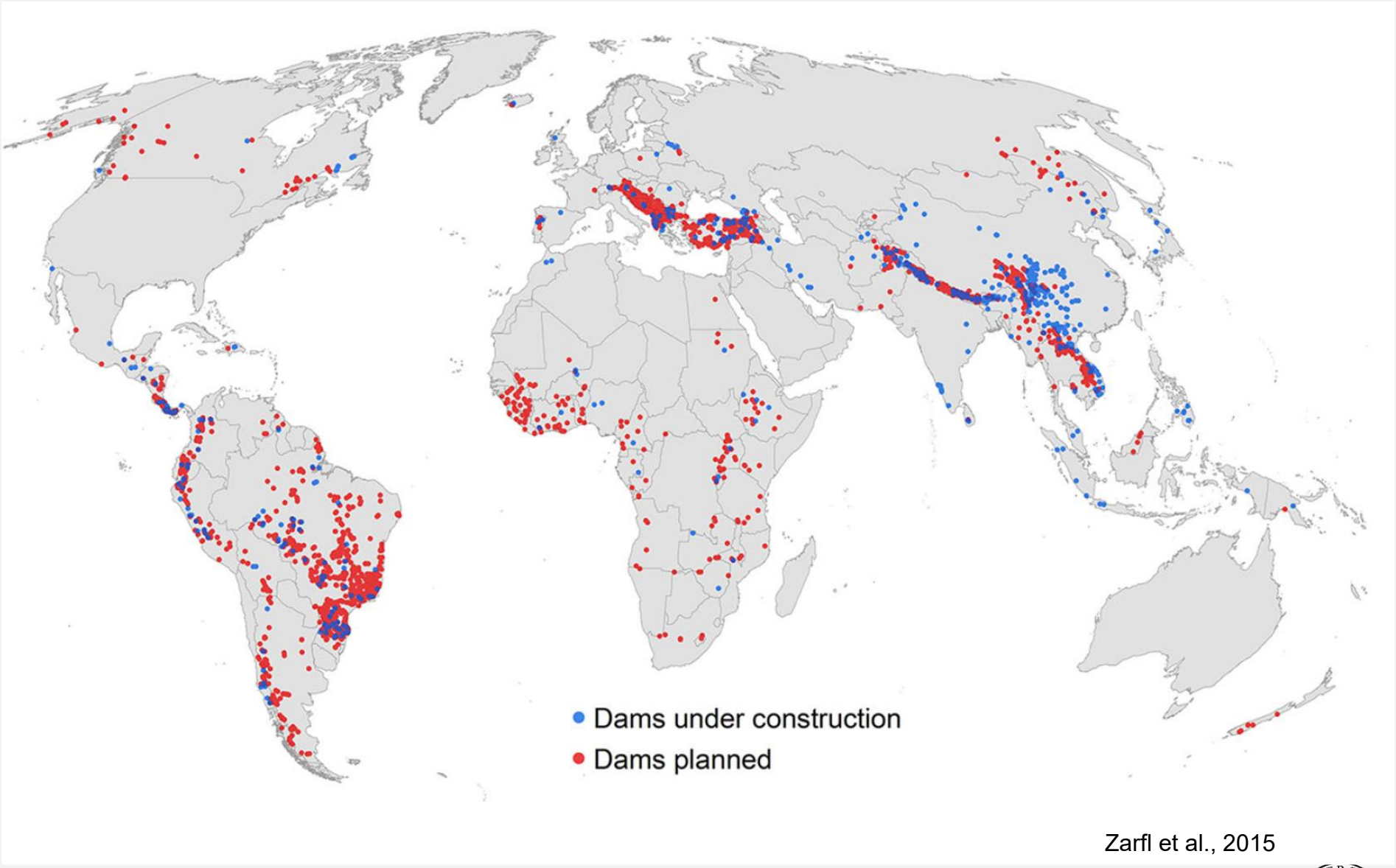
Sediment supply

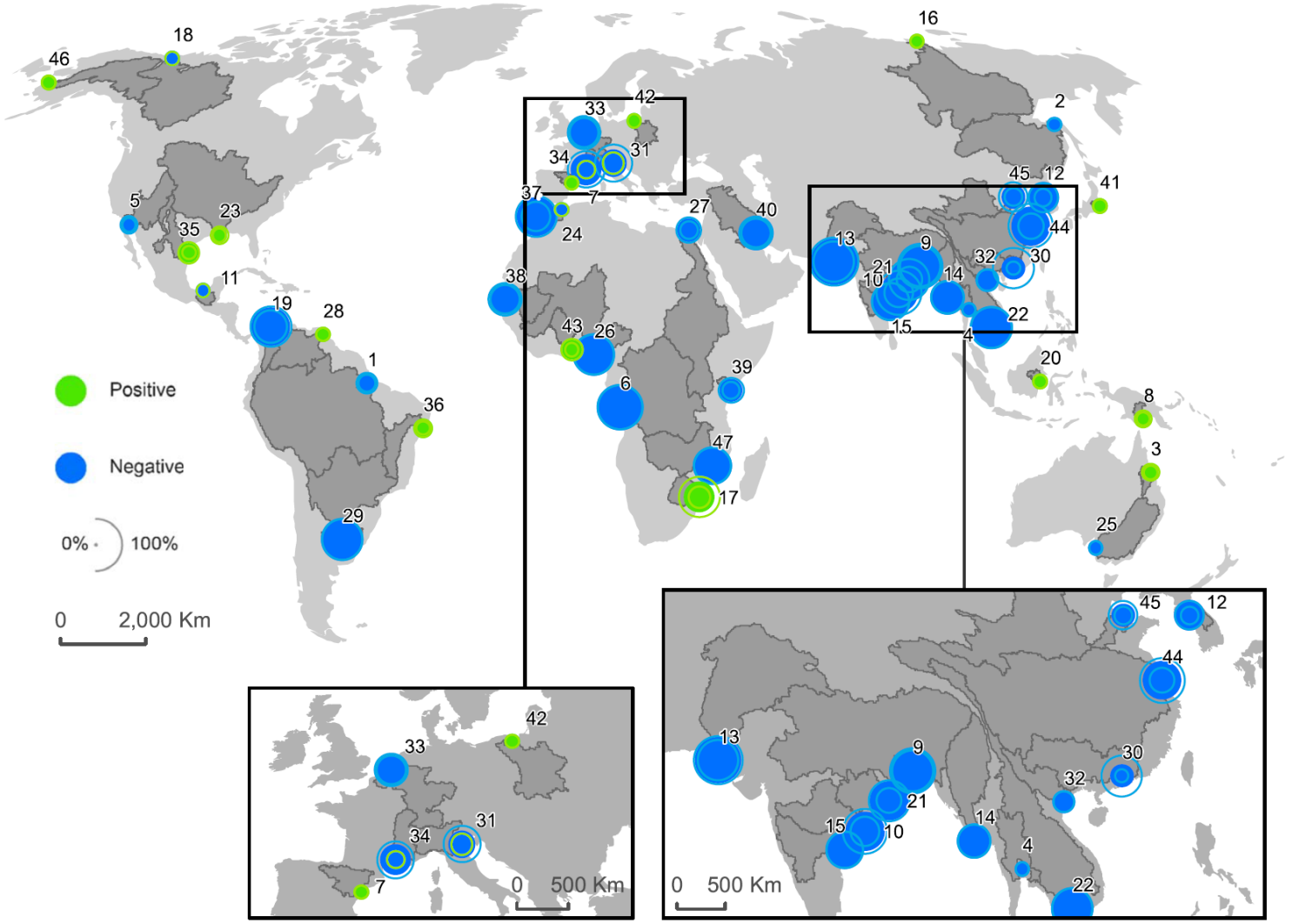


Sediment supply



Zarfl et al., 2015

Sediment supply



Dunn et al., 2019

Sediment supply

SAND MINING

Foto: Ted McGrath/Flickr.

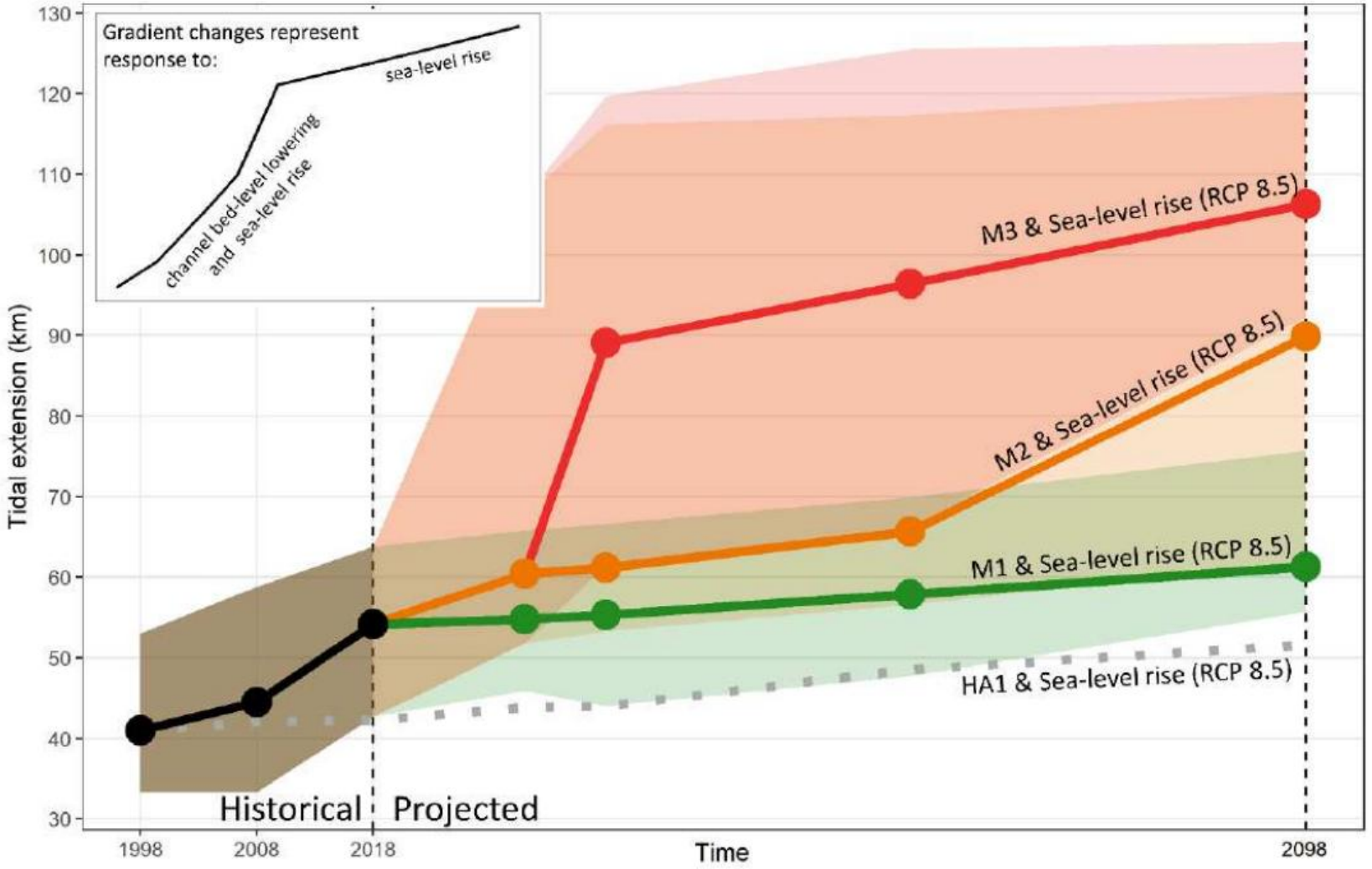
Image: buildingradar.com

Image: ArchDaily

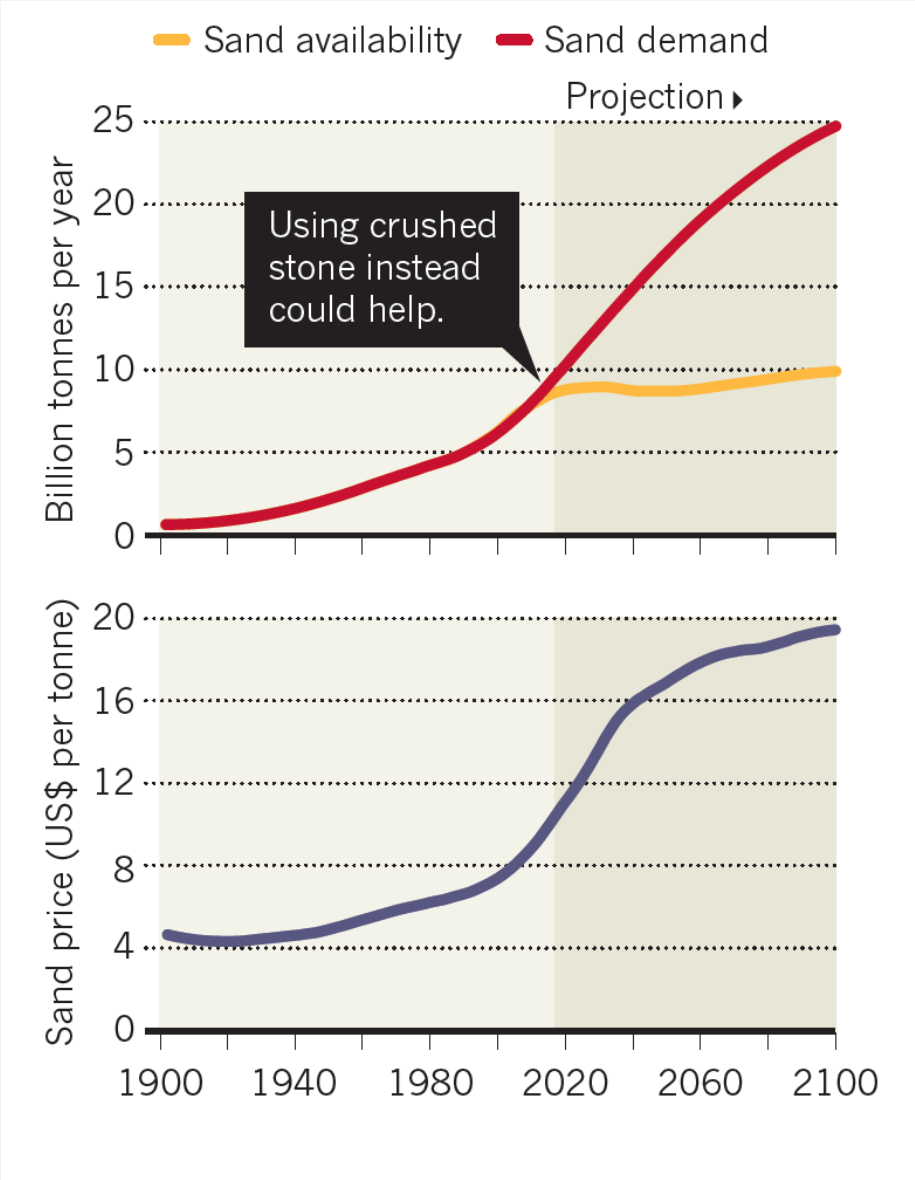
Yearly sand and gravel consumption for the industry, mainly concrete, glass, electronics: 32-50 billion tons.
The intens urbanizations will only increase in the future – hence increased sand consumption from rivers and the coastline.

SAND MINING MEKONG DELTA

Sediment supply



Vasilopoulos et al., 2020



Bendixen et al., 2019

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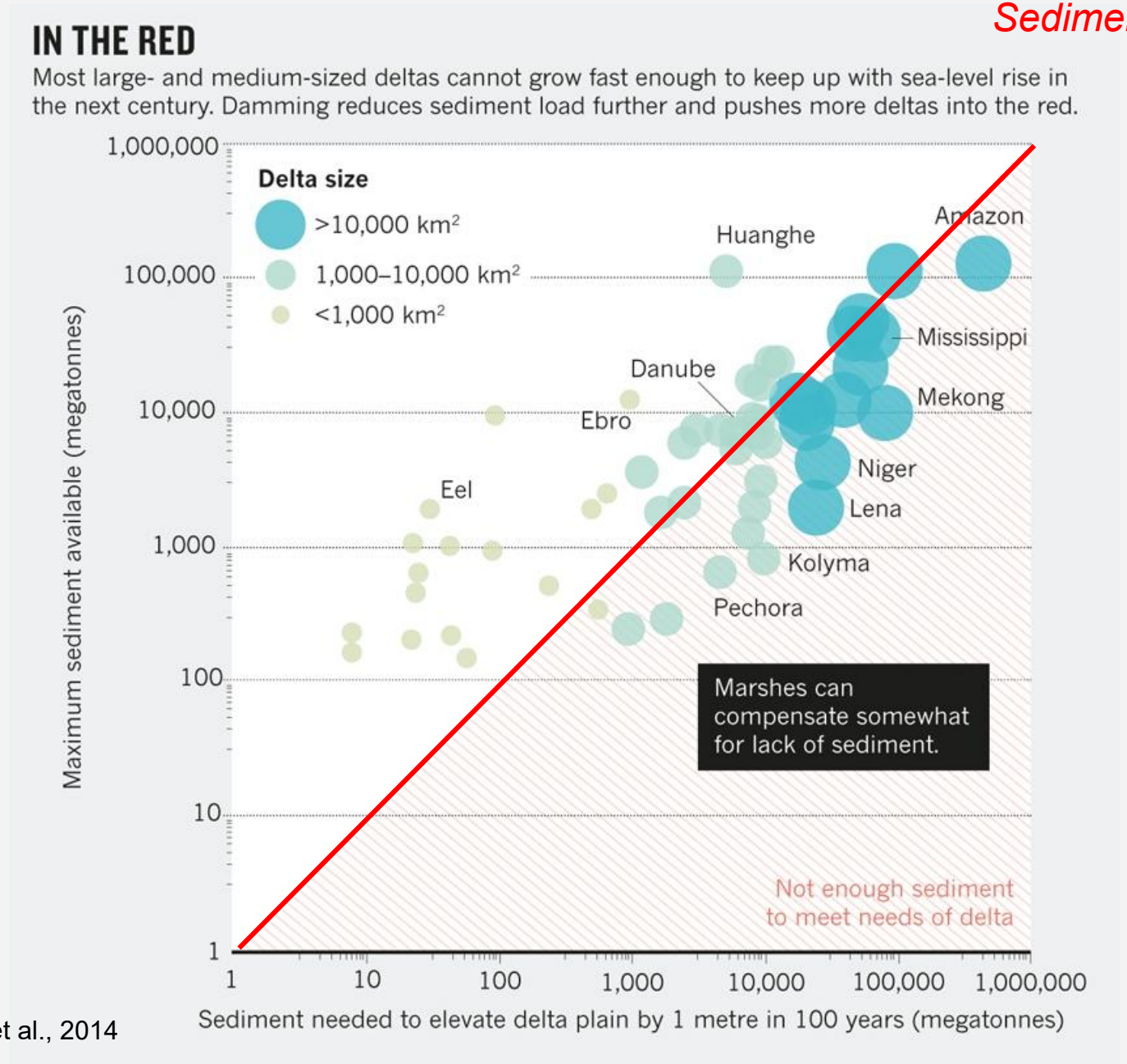

Giosan et al., 2014

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Blum and Roberts, 2009

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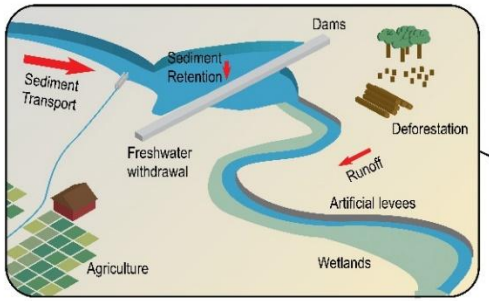
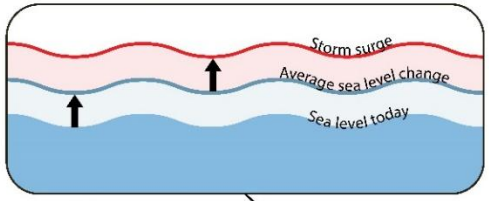
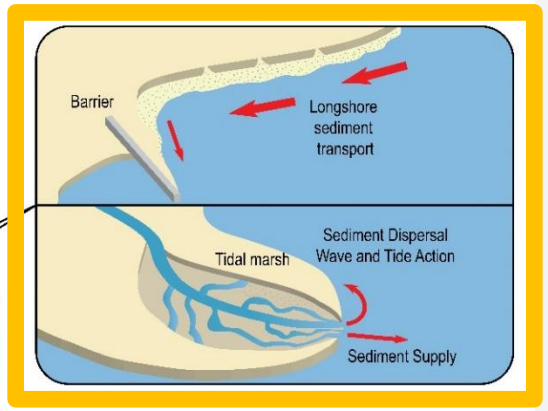
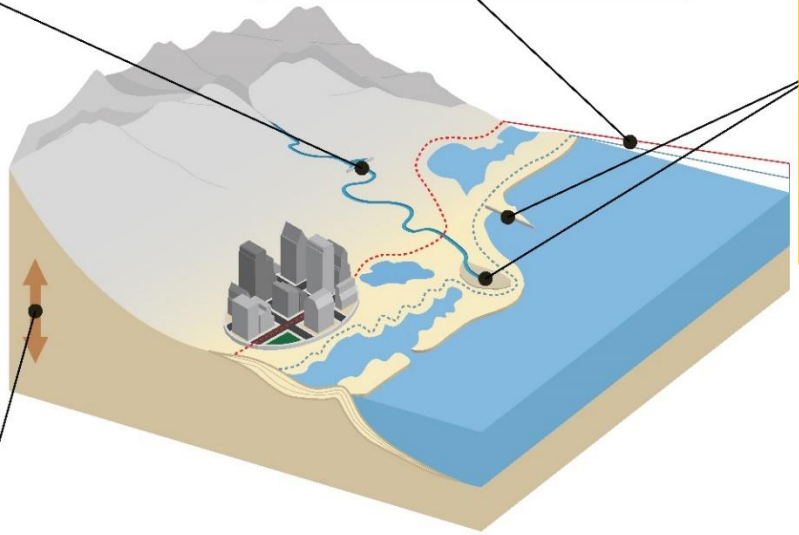
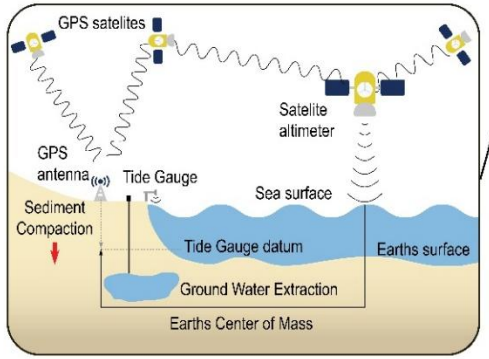
Sediment distribution











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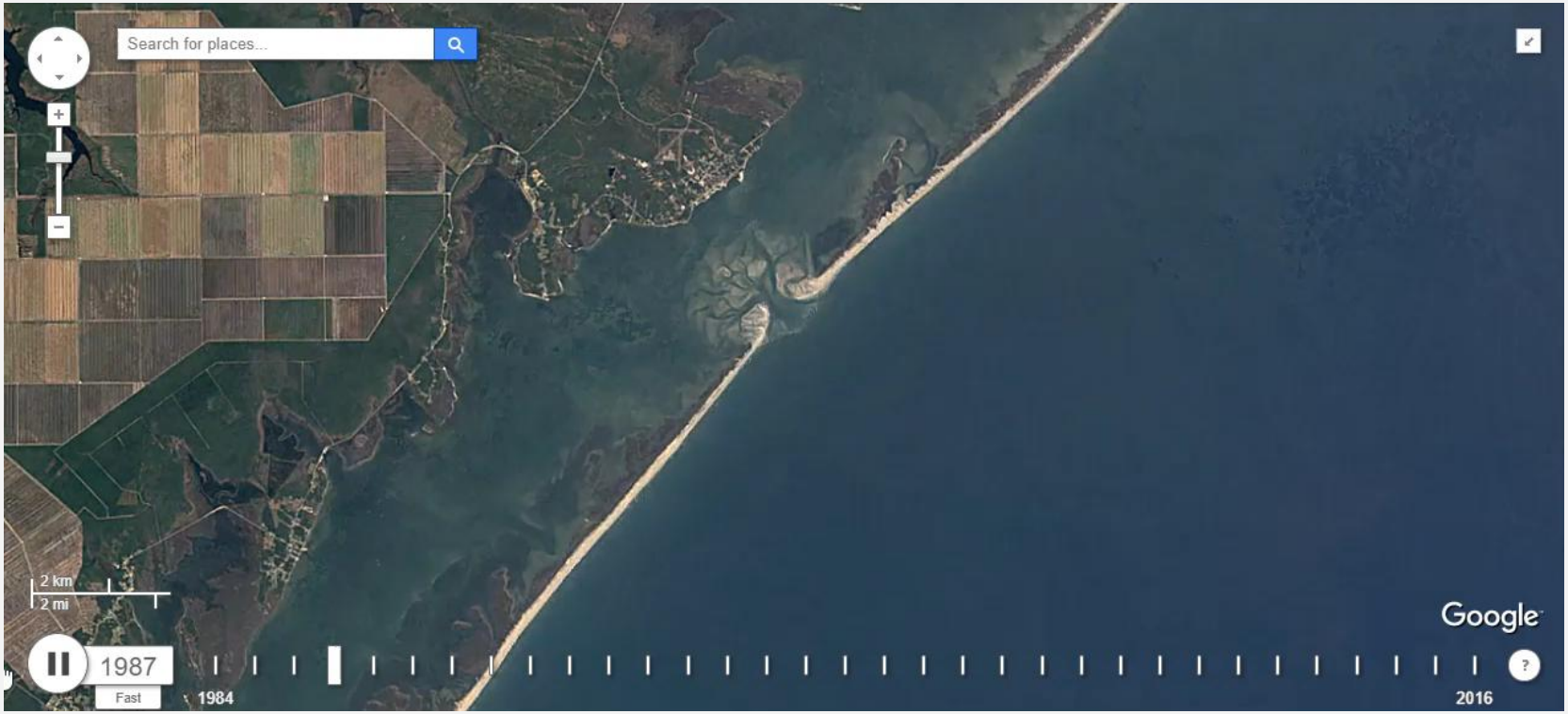


Cape lookout national seashore, North Carolina

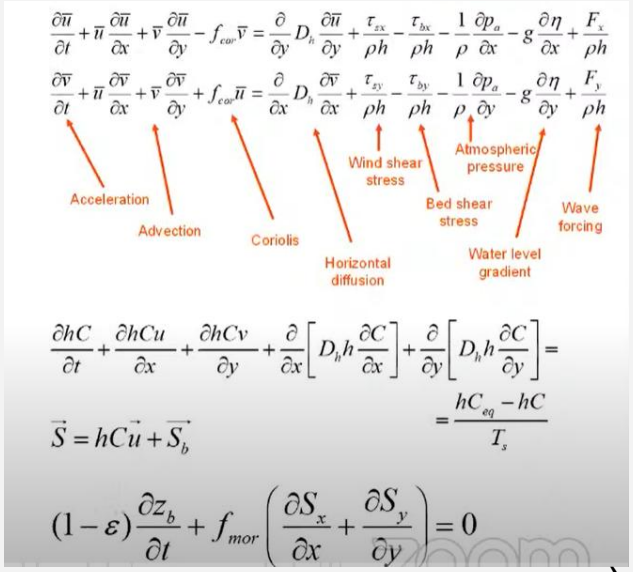
Sediment distribution

Process modelling

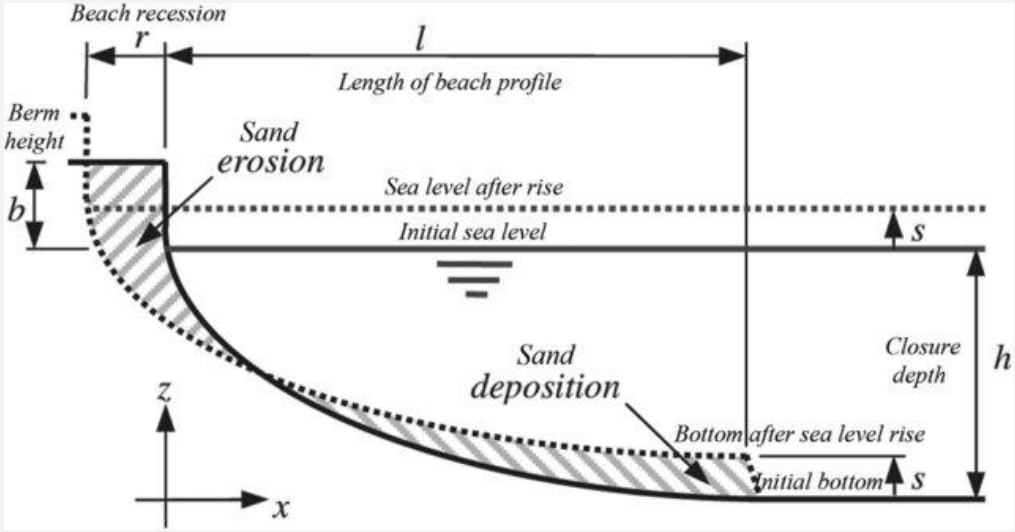
How to model future coastal landscapes?

?

Empirical modelling



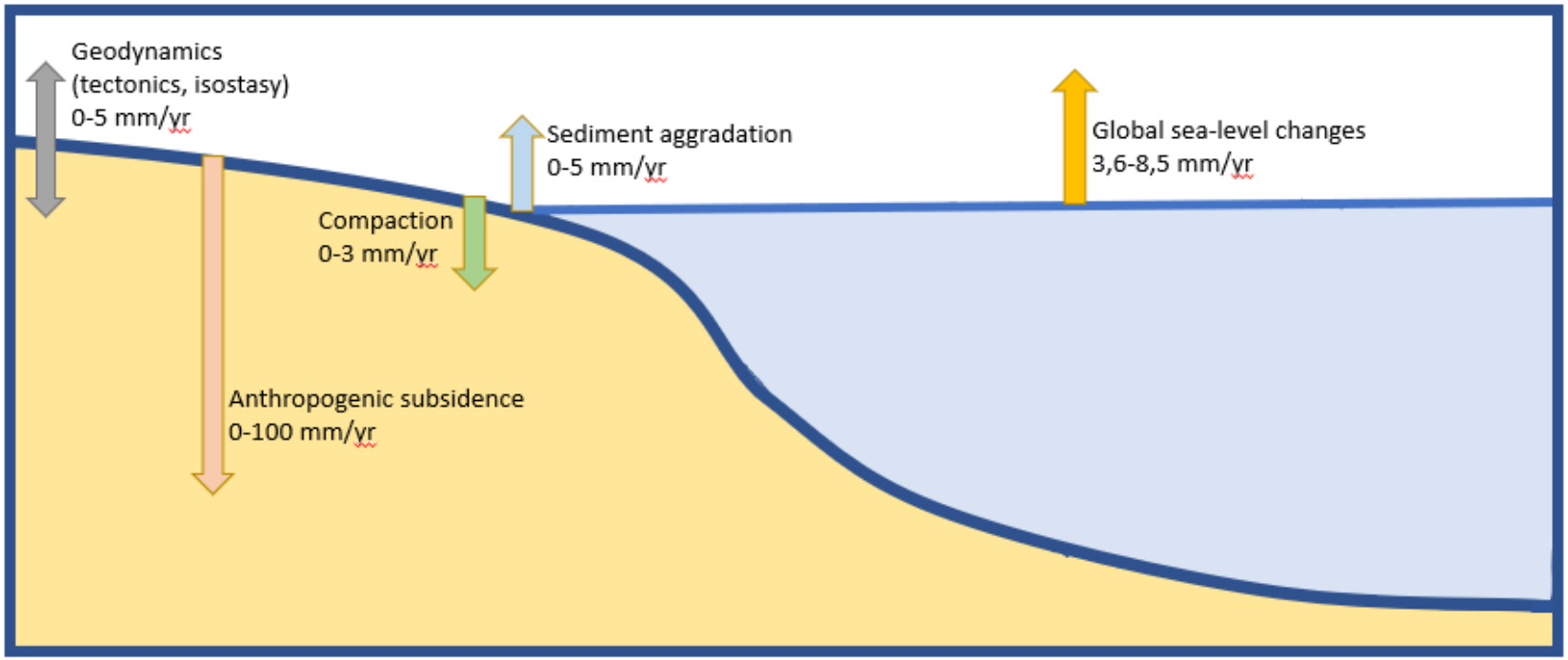
Dano Roelvink, YouTube (S2Stalks)



The Bruun Rule (modified after Langedijk 2008)

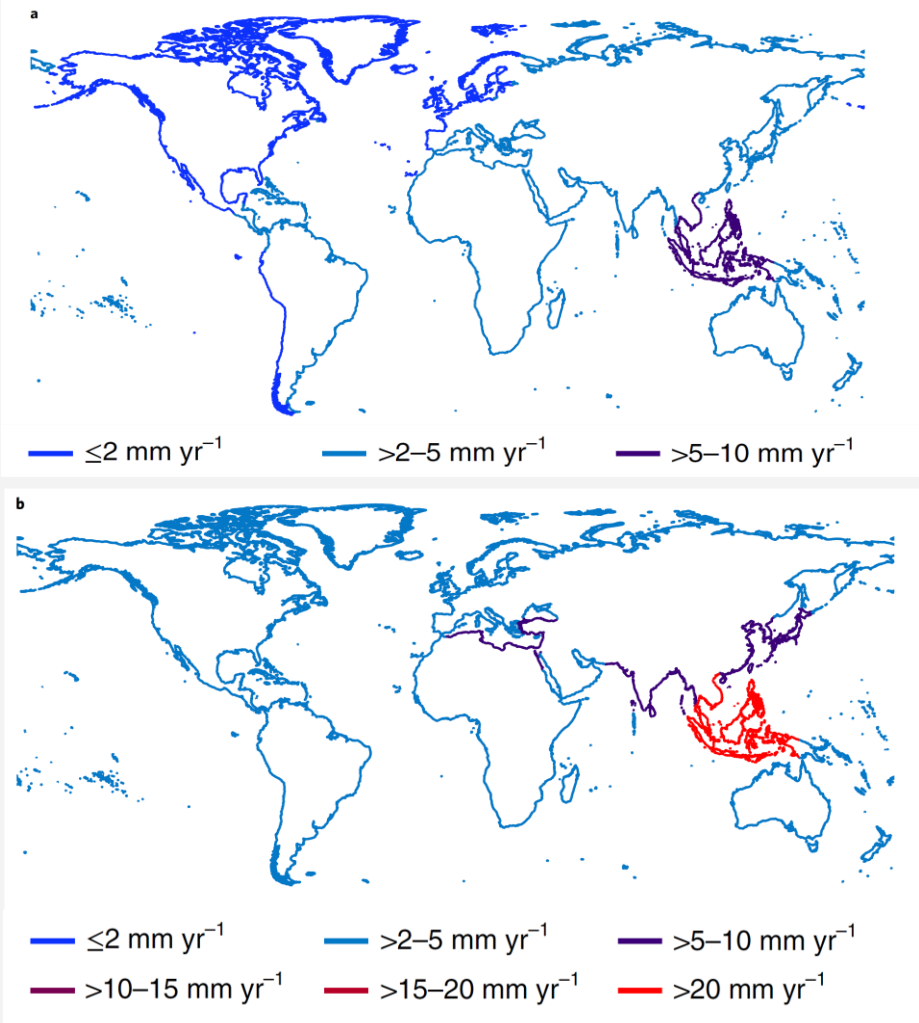
GEOSCIENCE IN DEMAND

Cape lookout national seashore, North Carolina

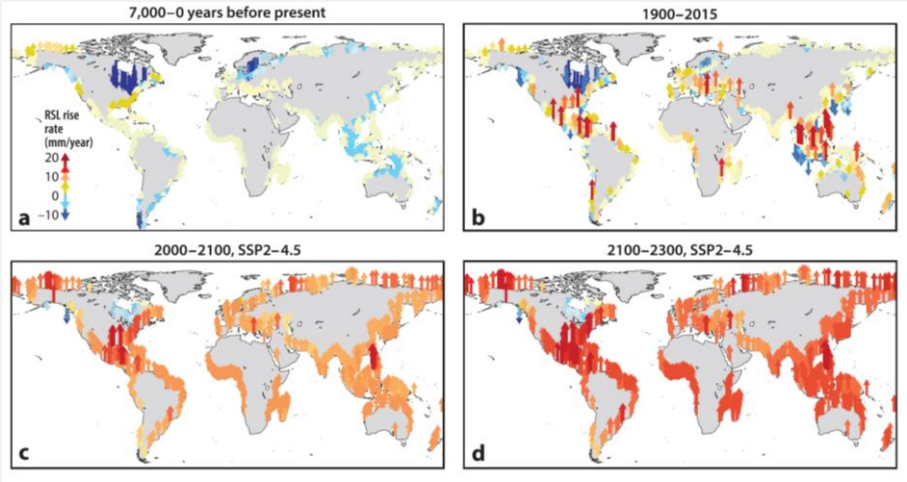


Processes affecting coastal change

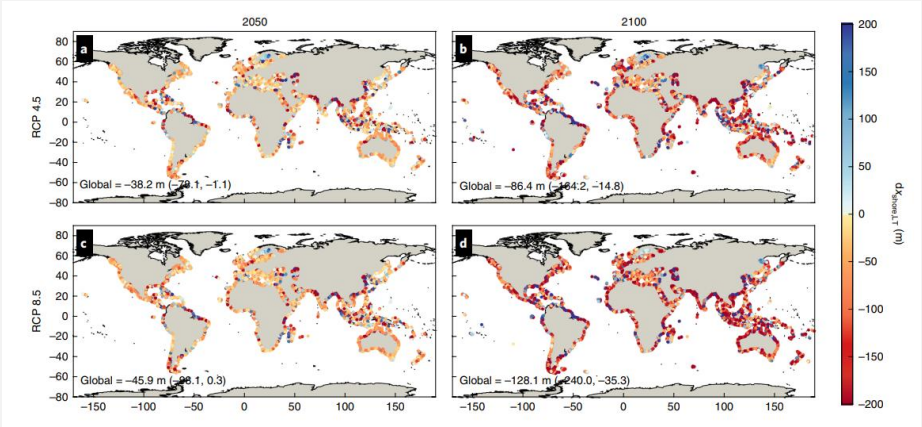
Global predictions



Nicholls et al., 2021



Nienhuis et al., 2023



Vousdoukas et al., 2020

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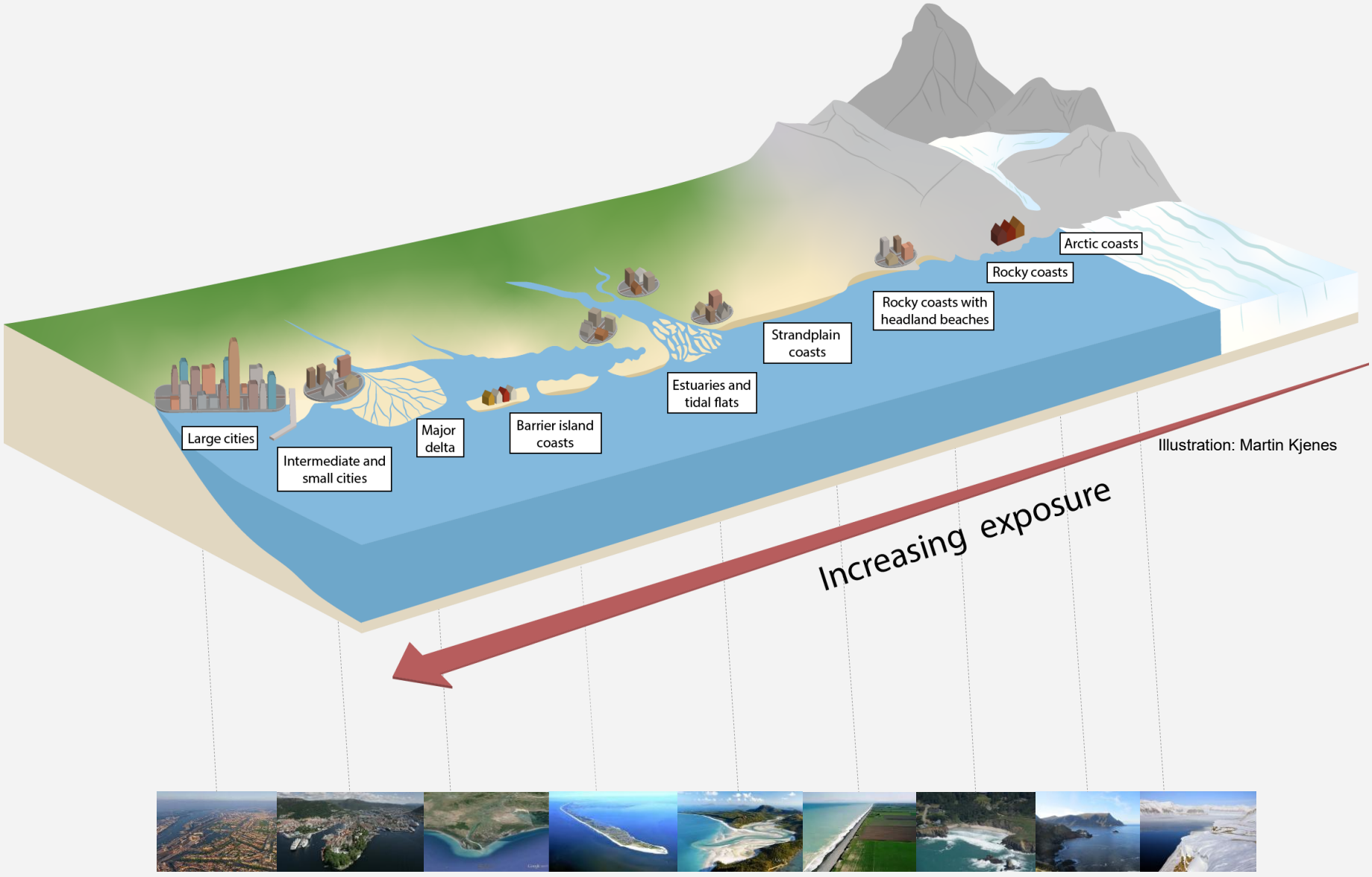
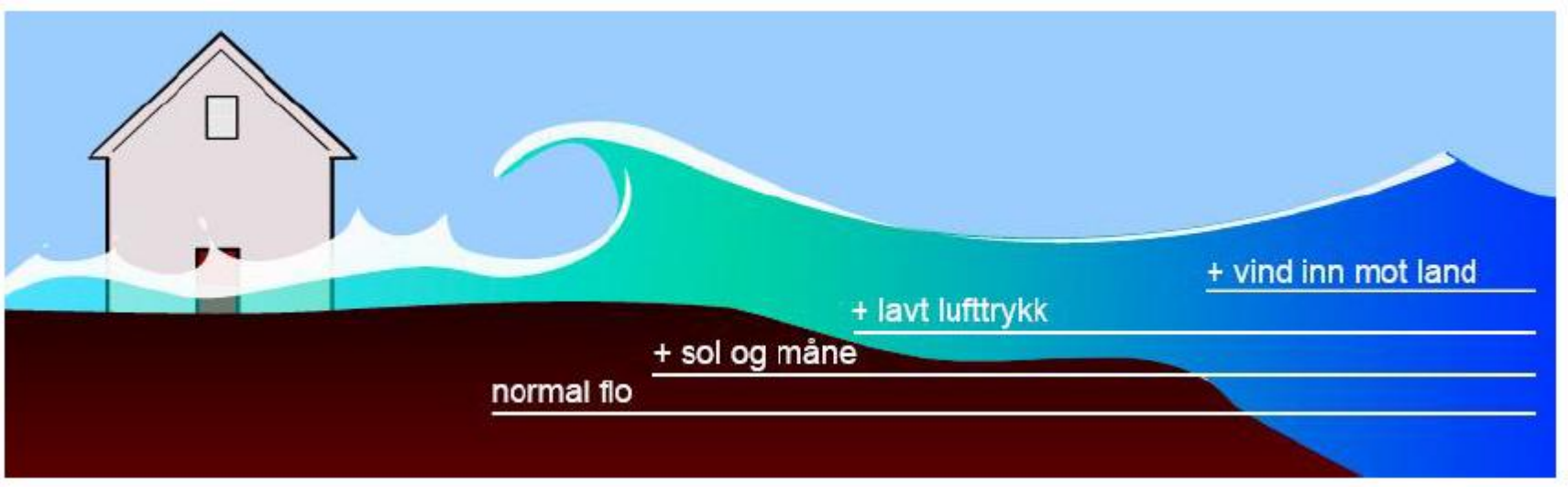

Large cities
Intermediate and small cities
Major delta
Barrier island coasts
Estuaries and tidal flats
Strandplain coasts
Rocky coasts with headland beaches
Rocky coasts
Arctic coasts
Increasing exposure
Illustration: Martin Kjenes

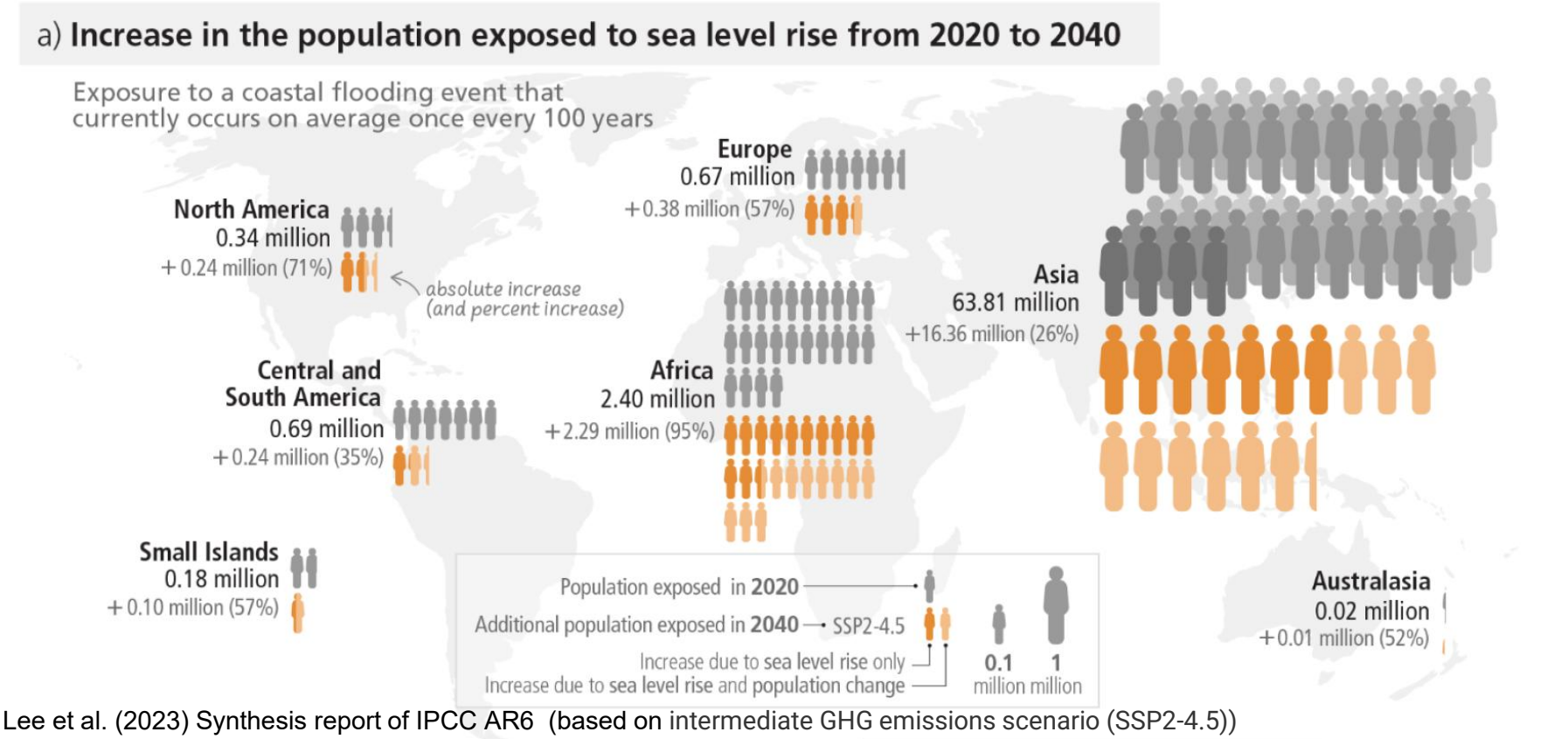
STORMFLO+TIDEVANN



Ronald Toppe/Scary Weather

Prosesser som bidrar til flomhendelser

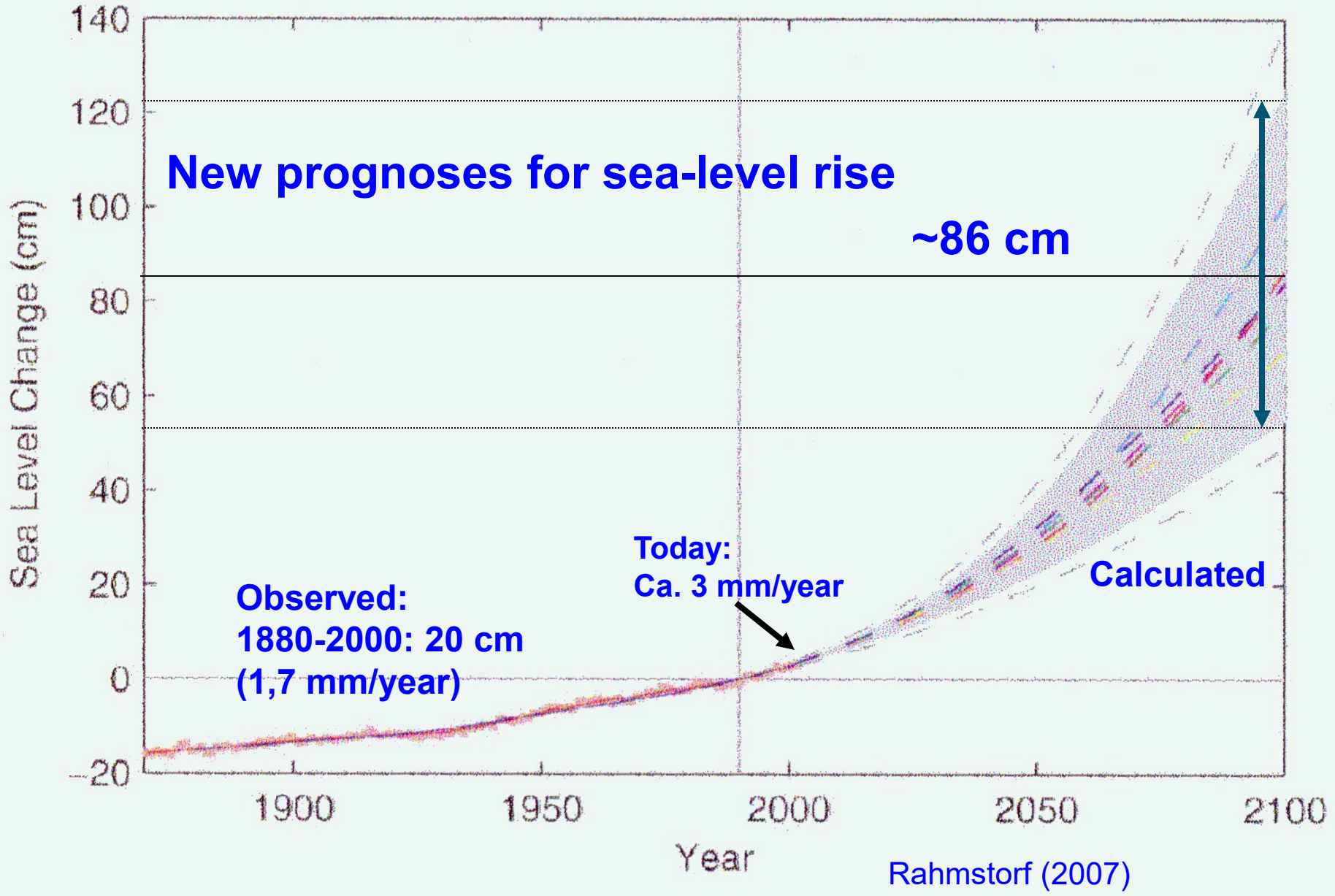
STORMFLO



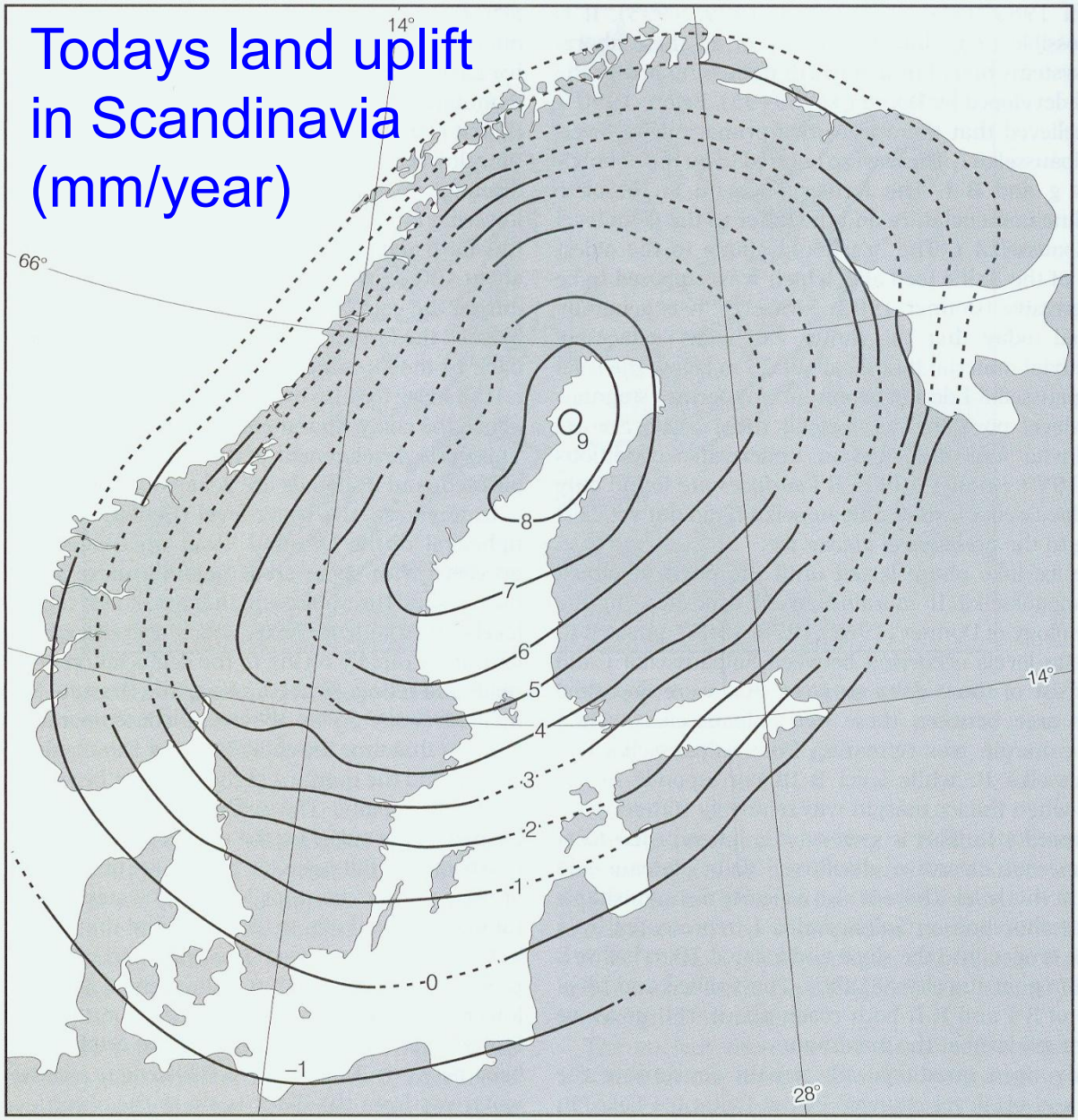
Lee et al. (2023) Synthesis report of IPCC AR6 (based on intermediate GHG emissions scenario (SSP2-4.5))

An actual example from Scandinavia

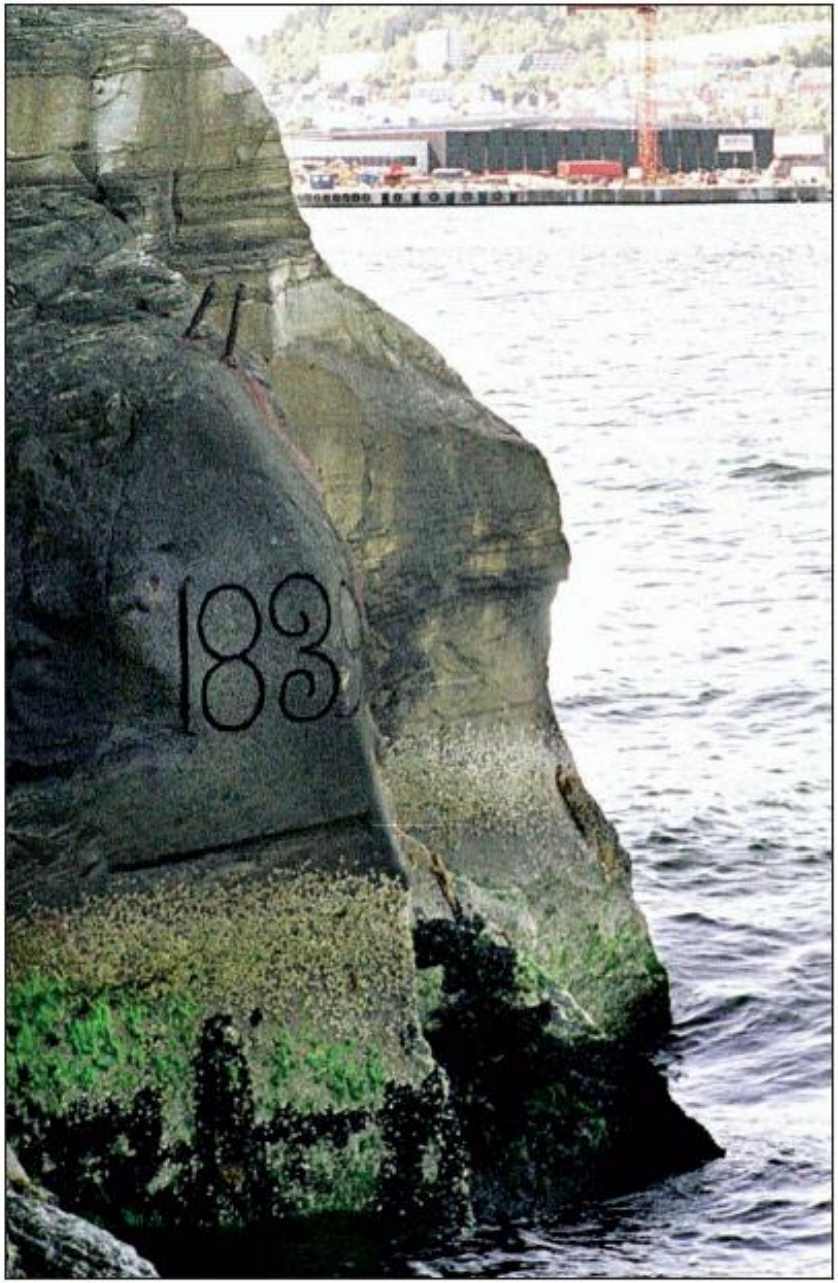
Slides courtesy of Atle Nesje


New prognoses for sea-level rise
~86 cm
Today:
Ca. 3 mm/year
Observed:
1880-2000: 20 cm
(1,7 mm/year)
Calculated
Sea Level Change (cm)
Year
140
120
100
80
60
40
20
0
-20
1900
1950
2000
2050
2100
Rahmstorf (2007)

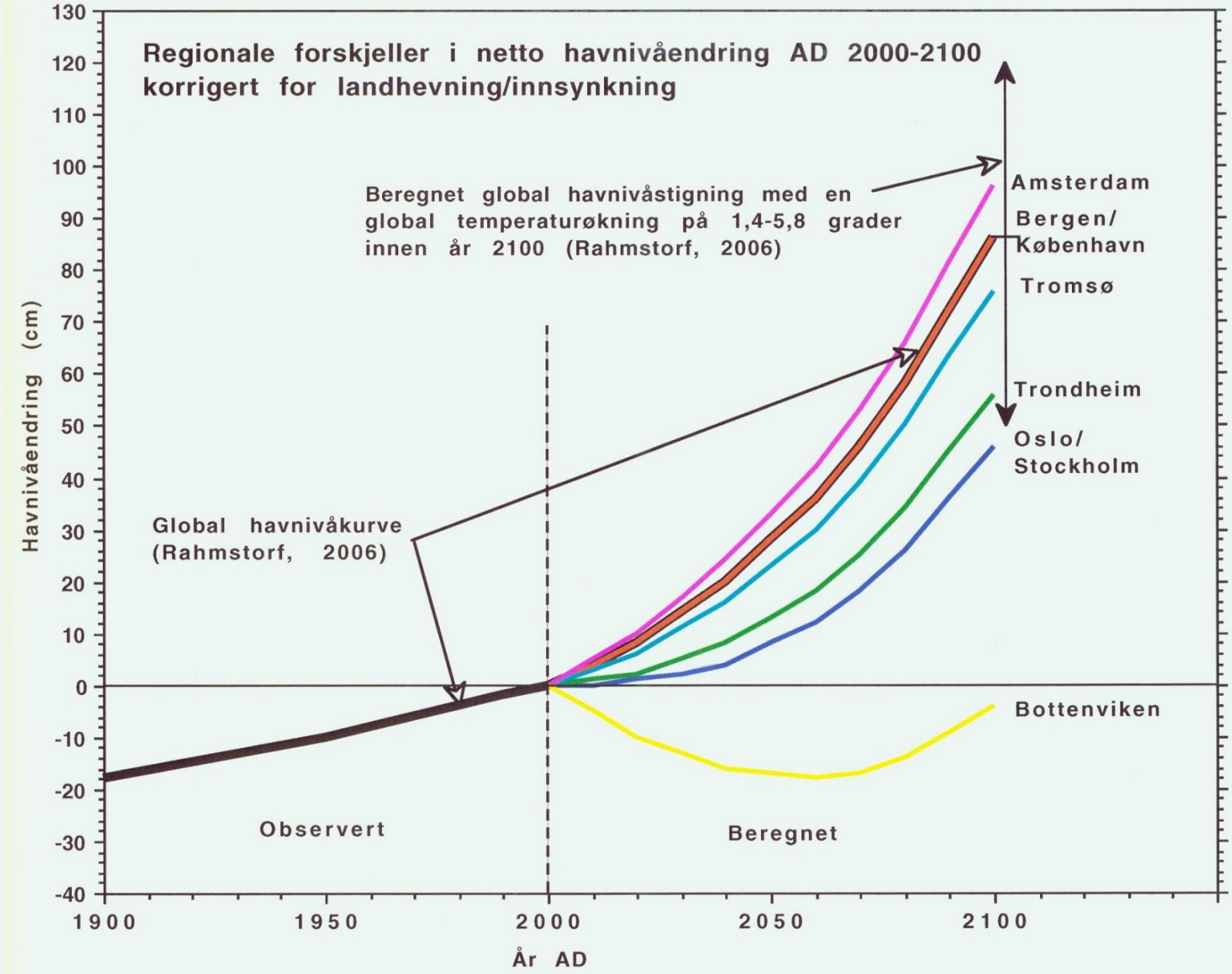
Todays land uplift in Scandinavia (mm/year)



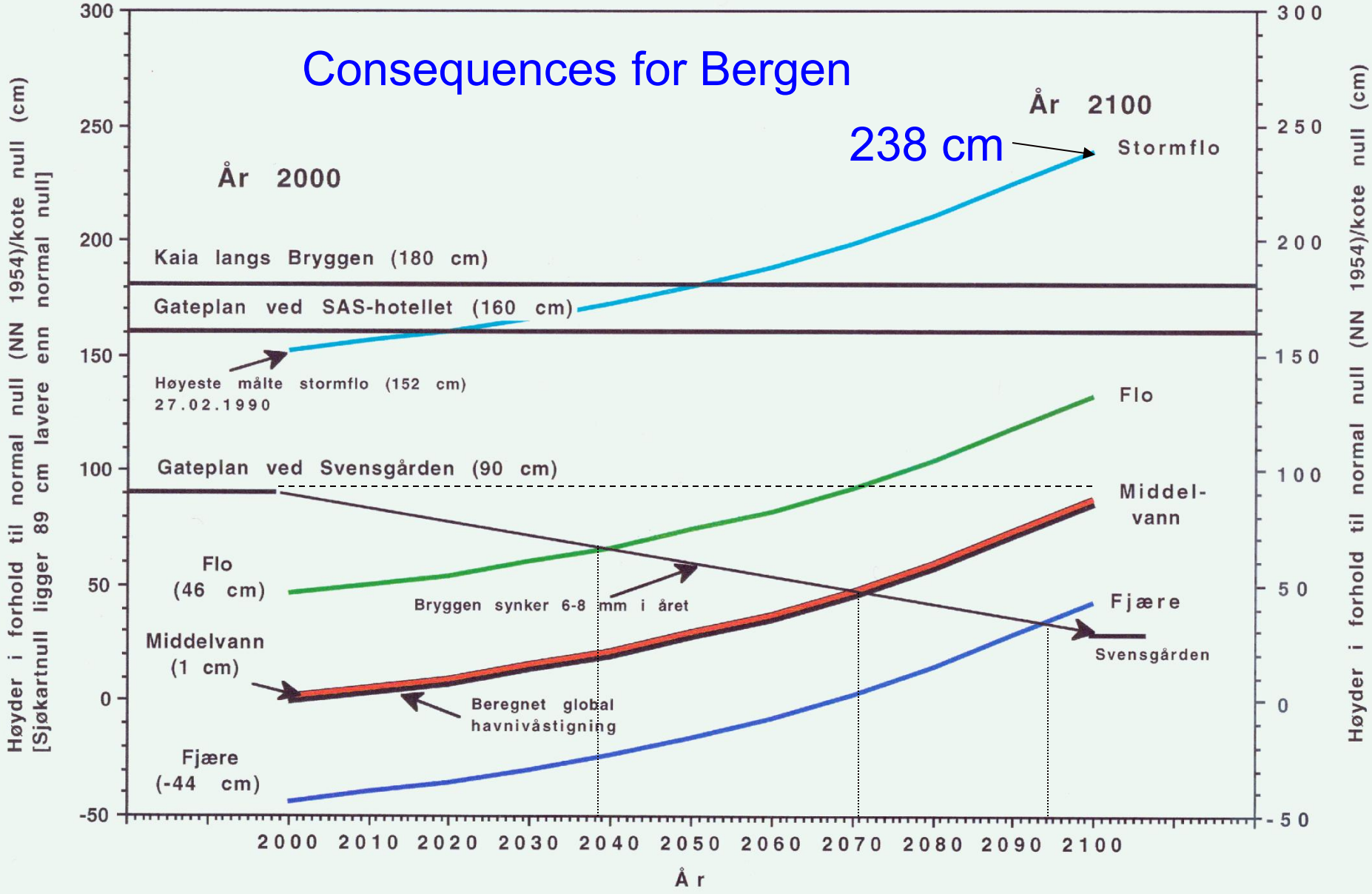
Institutt for geovitenskap
Department of Earth Science

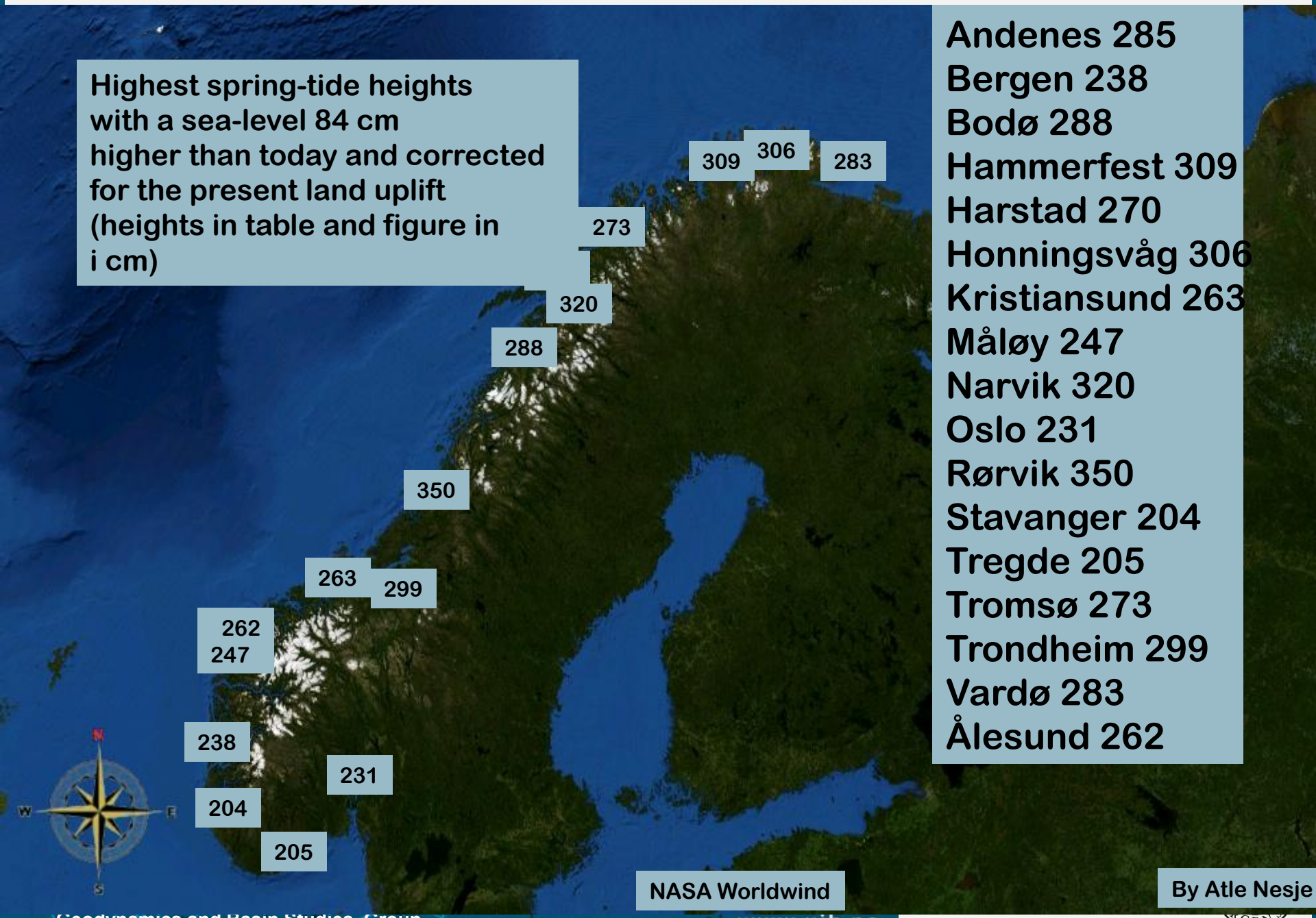


Naturhistorisk vegbok

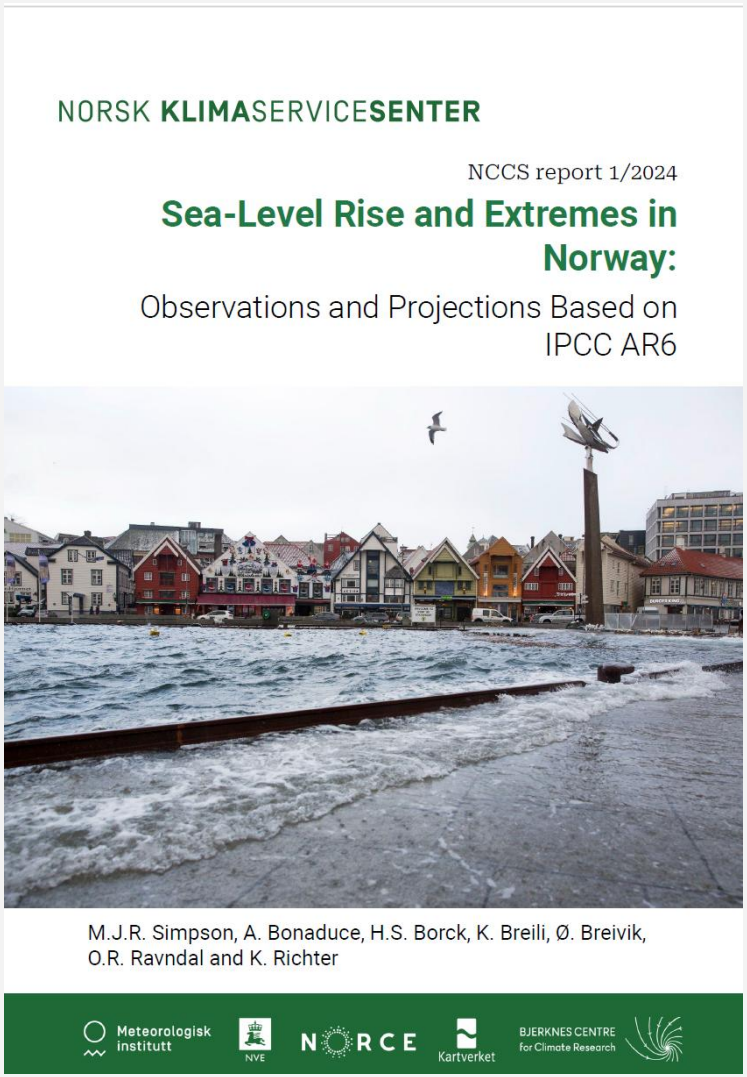

Regionale forskjeller i netto havnivåendring AD 2000-2100
korrigert for landhevning/innsynkning
Beregnet global havnivåstigning med en global temperaturøkning på 1,4-5,8 grader innen år 2100 (Rahmstorf, 2006)
Global havnivåkurve (Rahmstorf, 2006)
Amsterdam
Bergen/
København
Tromsø
Trondheim
Oslo/
Stockholm
Bottenviken
Observert
Beregnet
Havnivåendring (cm)
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
1900
1950
2000
2050
2100
År AD

Consequences for Bergen

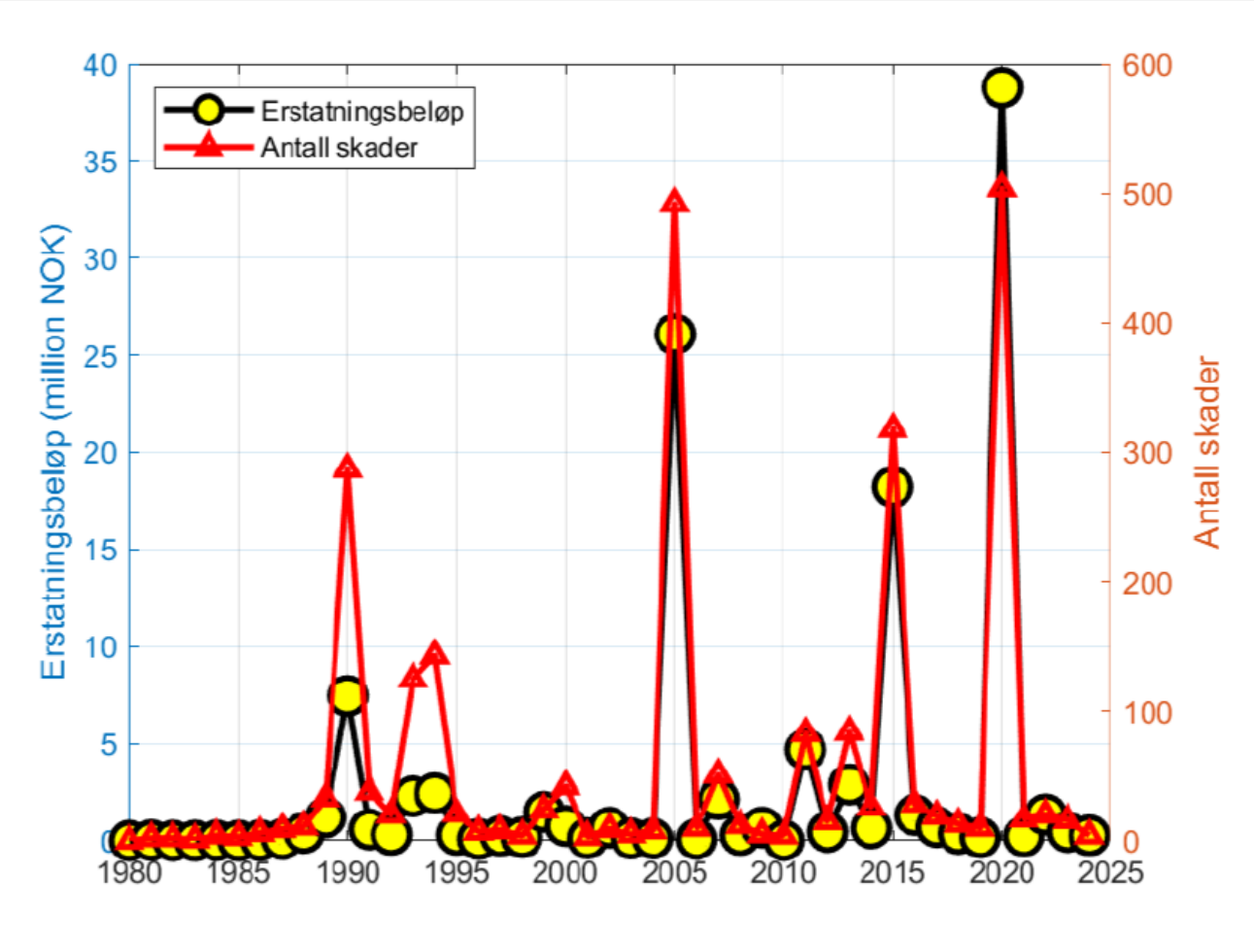



Highest spring-tide heights
with a sea-level 84 cm
higher than today and corrected
for the present land uplift
(heights in table and figure in
i cm)
309
306
283
273
320
288
350
263
299
262
247
238
231
204
205
N
W
E
S
Andenes 285
Bergen 238
Bodø 288
Hammerfest 309
Harstad 270
Honningsvåg 306
Kristiansund 263
Måløy 247
Narvik 320
Oslo 231
Rørvik 350
Stavanger 204
Tregde 205
Tromsø 273
Trondheim 299
Vardø 283
Ålesund 262
NASA Worldwind
By Atle Nesje

To viktige rapporter

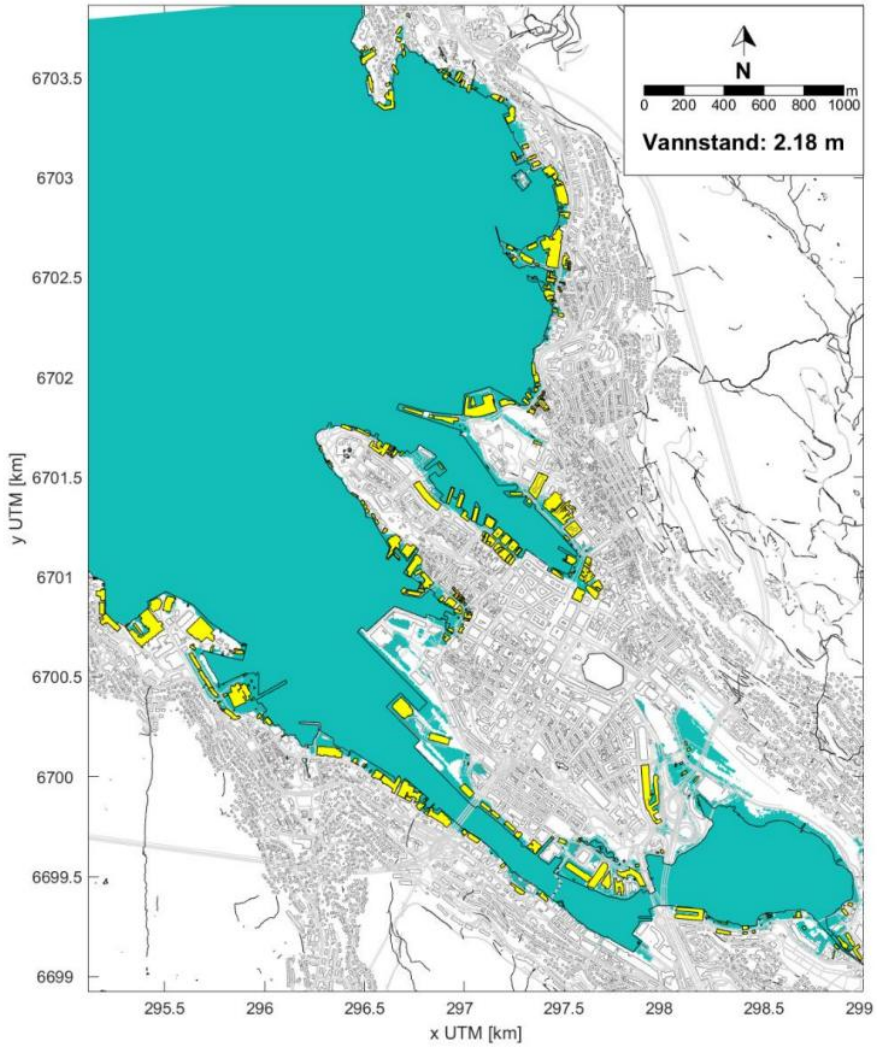


Illustrasjonen viser hvordan en såkalt 200-års stormflo kan gi oversvømmelser i Bergen i år 2100. Her er stormfloen lagt inn på kote 2.41 som anbefales som minimum gulvhøyde i fremtiden. ILLUSTRASJON: BERGEN KOMMUNE

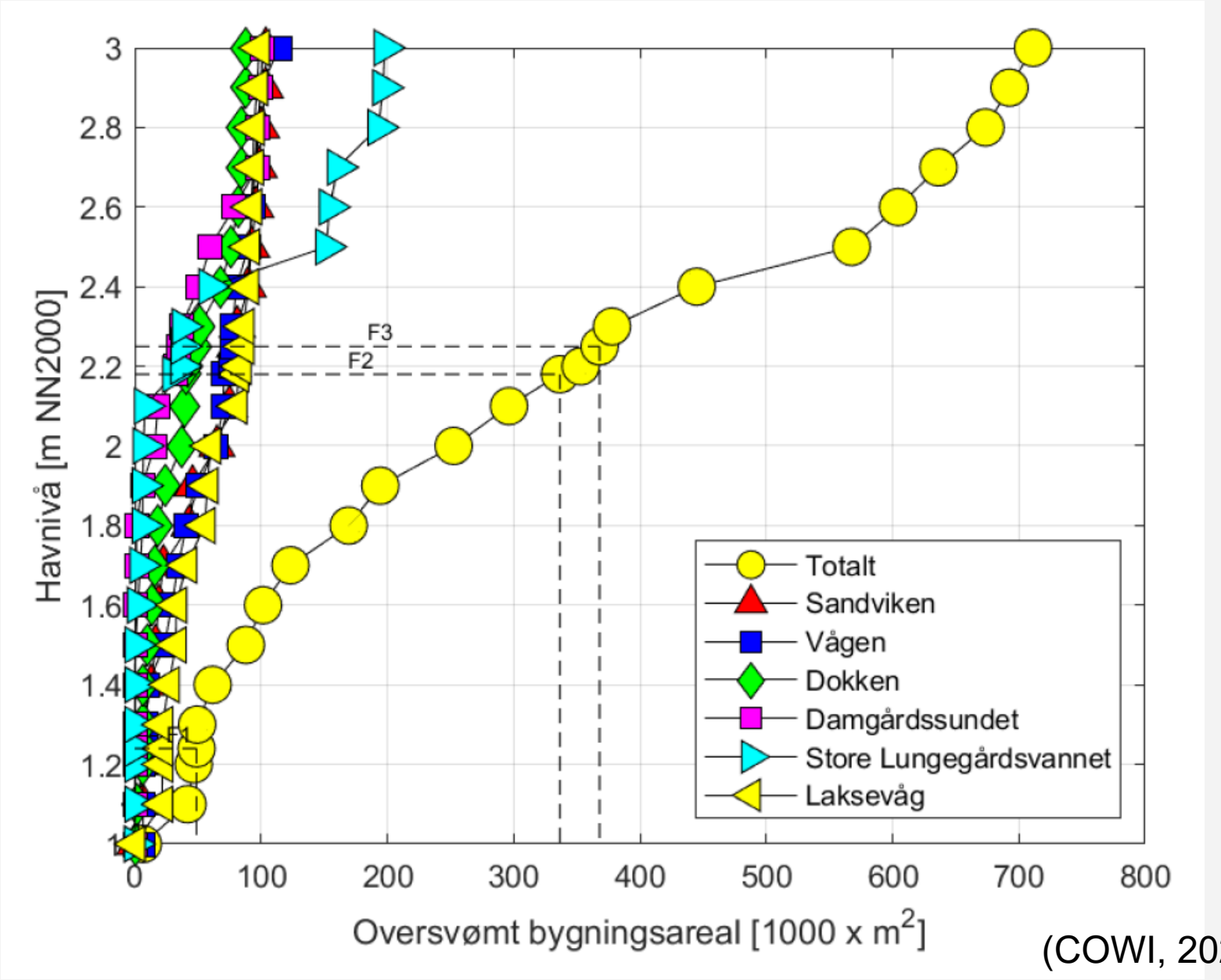


Erstatningsbeløp og antall skader i Hordaland fra private skader som følge av stormflo (NASK 2024)

Stormflo på Bryggen



År 2100:
Havnivåstigning 81 cm + 200-års stormflo= 218cm.
Gule markerte bygninger oversvømmes ved denne vannstanden.(COWI, 2024).


Havnivå [m NN2000]
Oversvømt bygningsareal [1000 x m^2]
F1
F2
F3
Totalt
Sandviken
Vågen
Dokken
Damgårdssundet
Store Lungegårdsvannet
Laksevåg

(COWI, 2024)

Flomvern Bergen (COWI, 2024)

Hvorfor er vi heldige i Norge (igjen!)

1. Høyt kystrelieff og glasioisostatisk heving

2. Lite løse sedimenter

3. Drahjelp fra smelting på Grønland

4. Breenes skulpturering av landskapet: Naturlige vannreservoarer

5. Mye nedbør

6. Slipper tropiske sykloner

7. God økonomi

Langt frem i tid

- Glasioisostatisk landhevning avtar
- Smelting av (Vest) Antarktis:
  full effekt i Norge
- Oppbygning av iskapper er langsommere enn nedsmelting
- Havnivåstigning vil fortsette
- Neste istid minst 50 000 år frem i tid

Landsat Image: Mosaic of Antarctica team